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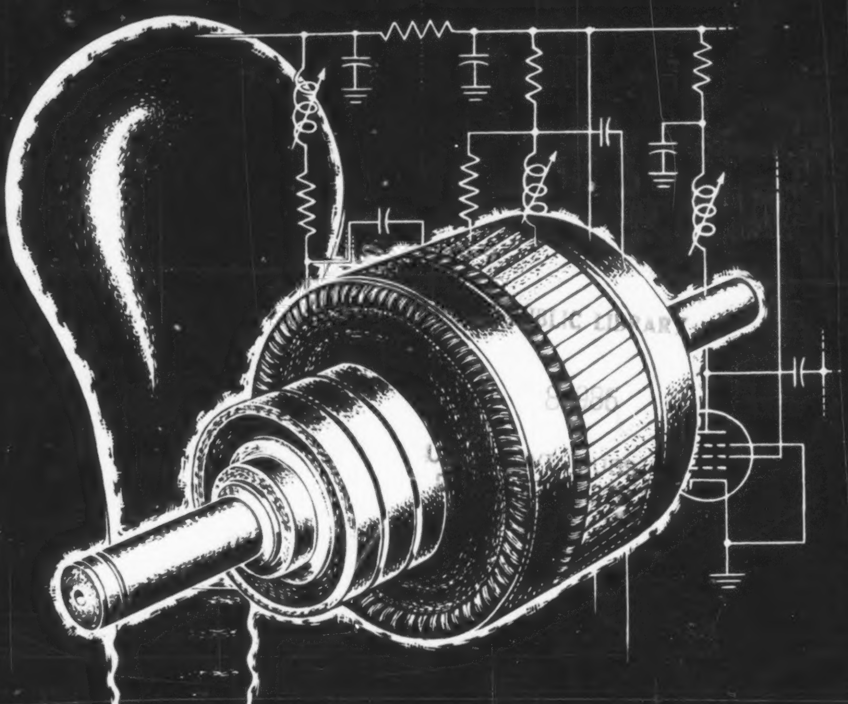

ELECTRICIAN'S MATE 1 & C

RATE TRAINING MANUAL AND NONRESIDENT CAREER COURSE
NAVAL EDUCATION AND TRAINING COMMAND

NAVEDTRA 10547-E

DISTRIBUTION STATEMENT A

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Although the words "he," "him," and "his" are used sparingly in this manual to enhance communication, they are not intended to be gender driven not to affront or discriminate against anyone reading *Electrician's Mate 1 & C*, NAVEDTRA 10547-E.

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Naval Education And Training Program Development Center

ELECTRICIAN'S MATE 1 & C

NAVEDTRA 10547-E

DEPARTMENT OF THE NAVY
CHIEF OF NAVAL EDUC AND TNG

1985 Edition Prepared by
EMCS Gerald F. Girtman

PREFACE

This rate training manual and nonresident career course (RTM/NRCC) form a self-study program that will enable the ambitious Electrician's Mate to prepare himself for the increased responsibilities of a senior petty officer. Among these responsibilities are the abilities to operate, maintain, and repair voltage and frequency regulating equipment, auxiliary propulsion equipment and electrohydraulic load-sensing speed governors. In addition, he must prepare himself for higher responsibility when dealing with administration, supervision, and training.

This RTM/NRCC package is designed for individual study and not formal classroom instruction. The RTM presents subject matter that relates directly to the occupational qualifications of the Electrician's Mate rating. The NRCC provides guidance in studying the RTM with learning objectives and study items that emphasize the important material.

This RTM/NRCC was prepared by the Naval Education and Training Program Development Center, Pensacola, Florida for the Chief of Naval Education and Training.

1985 Edition

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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

CONTENTS

Chapter Page

1. Administration, Supervision, and Training 1-1
2. Inspections and Maintenance 2-1
3. Engineering Casualty Control.......................... 3-1
4. Voltage and Frequency Regulation 4-1
5. Electrohydraulic Load-Sensing Speed Governors 5-1
6. Visual Landing Aids................................... 6-1
7. Auxiliary Propulsion Equipment 7-1

Appendix

I. Temperature Conversion List AI-1

II. The Metric System AII-1

Index I-1

Nonresident Career Course follows Index

CREDITS

The illustrations indicated below are included in this edition of *Electrician's Mate 1 & C* through the courtesy of the designated source. Permission to use these illustrations is gratefully acknowledged. Permission to reproduce illustrations and other materials in this publication should be obtained from the source.

Source	Figures
Woodward Governor Company	5-1, 5-2, 5-4, 5-5, 5-12, 5-13, 5-14, 5-15, 5-16, 5-17, 5-18, 5-19, 5-20, 5-21, 5-22, 5-23

ELECTRICIAN'S MATE 1 & C OCCUPATIONAL STANDARDS

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
ELECTRICIAN'S MATE FIRST CLASS (EM 1)		
24 ELECTRICAL MAINTENANCE		
24474	TROUBLESHOOT AND REPAIR ELECTRIC GOVERNOR SYSTEMS	5
24475	TEST AND REPAIR ELECTROHYDRAULIC CONTROLLERS	5
24479	CLASSIFY CASUALTIES OF MOTION PICTURE PROJECTION EQUIPMENT AS REPAIRABLE AT SHIPBOARD OR TENDER LEVEL	2
24491	SELECT SUBSTITUTE ELECTRICAL COMPONENTS	2
35 ADMINISTRATION		
35125	RECORD FULL POWER AND ECONOMY TRIAL DATA	2
44 TRAINING		
44017	INSTRUCT PERSONNEL IN OPERATION, MAINTENANCE, AND CASUALTY CONTROL PROCEDURES	3
44018	CONDUCT CASUALTY CONTROL DRILLS	3
50 MAINTENANCE PLANNING AND QUALITY ASSURANCE		
50934	REVIEW ELECTRICAL OPERATING LOGS AND MAINTENANCE RECORDS	1
50978	REVIEW COMPLETED MAINTENANCE DATA SYSTEM (MDS) FORMS	1
50987	PREPARE WEEKLY SCHEDULES OF PREVENTIVE MAINTENANCE	2
50988	PREPARE WORK REQUESTS	2
50997	PERFORM QUALITY ASSURANCE INSPECTIONS	2
54 LOGISTICS SUPPORT		
54057	POST CHANGES TO COSAL	2
54699	INVENTORY AND TURN IN EQUIPMENT, SPARE PARTS, AND MATERIAL	2
CHIEF ELECTRICIAN'S MATE (EMC)		
24 ELECTRICAL MAINTENANCE		
24444	INSPECT WORK AREAS, TOOLS, AND EQUIPMENT	4, 5
24476	INSPECT, TEST, AND DIRECT REPAIR OF DEGAUSSING ELECTRICAL EQUIPMENT	1
24482	INSPECT, TEST, AND DIRECT REPAIR OF STATIC MAGNETIC AMPLIFIER EQUIPMENT	4

NUMBER	OCCUPATIONAL STANDARD	CHAPTER
CHIEF ELECTRICIAN'S MATE (EMC)—CONTINUED		
24 ELECTRICAL MAINTENANCE—CONTINUED		
24483	INSPECT, TEST, AND DIRECT REPAIR OF VOLTAGE AND SPEED REGULATORS ASSOCIATED WITH 400-HERTZ SYSTEMS	4
24484	INSPECT, TEST, AND DIRECT REPAIR OF STATIC INVERTERS	4
24485	TEST AND DIRECT MAINTENANCE AND REPAIR OF ELECTRICAL DISTRIBUTION SYSTEMS	1, 2, 3, 4, 7
24487	SUPERVISE TAKING OF READINGS AND TESTS	1, 2
38 ADMINISTRATION		
38945	ASSIGN PERSONNEL TO WATCH STATIONS	1
38946	SUPERVISE MAINTENANCE OF LOGS AND RECORDS	1
38947	PREPARE SHIP TRIAL REPORTS	2
38948	PREPARE CASUALTY REPORTS (CASREPS), CASUALTY CORRECTION REPORTS (CASCORS) AND SITUATION REPORTS (SITREPS)	2
38949	MAINTAIN FILES	1, 2
38950	REVIEW OVERHAUL WORK PACKAGE	1
38953	SUPERVISE PERSONNEL OPERATING AND MAINTAINING ELECTRICAL SYSTEMS	1, 2, 3, 4, 5, 6, 7
38954	SUPERVISE THE QUALIFICATIONS OF WATCH STANDERS	1, 2
42 GENERAL WATCH STANDING		
42340	STAND ENGINEERING OFFICER OF THE WATCH	1, 2, 3
48 MATERIAL CASUALTY CONTROL		
48036	SUPERVISE CASUALTY CONTROL PROCEDURES	3
50 MAINTENANCE PLANNING AND QUALITY PROCEDURES		
50901	REVIEW SHIP-TO-SHOP MAINTENANCE PROGRESS REPORTS	2
50902	VERIFY COMPLIANCE WITH QUALITY ASSURANCE PROCEDURES	2
50903	VERIFY ACCURACY OF THE PMS PACKAGE	2
50984	ESTIMATE TIME AND SUPPORT REQUIRED FOR REPAIR OF ELECTRICAL SYSTEMS	1, 6, 7
50988	PREPARE QUARTERLY SCHEDULES OF PREVENTIVE MAINTENANCE	2
54 LOGISTICS SUPPORT		
54711	POST CHANGES TO SECAS AND SUBMIT REPORTS	2
54870	SCREEN REQUISITIONS	2
88 ELECTRICAL/ELECTRONIC EQUIPMENT OPERATION		
88250	SUPERVISE FULL POWER AND ECONOMY TRIALS	2

CHAPTER 1

ADMINISTRATION, SUPERVISION, AND TRAINING

The higher you go in the Navy, the more responsibility you have dealing with administration, supervision, and training. This chapter addresses some of your administrative and supervisory responsibilities as an EM1 or EMC. It also discusses aspects of your responsibility for training others.

Although it is possible to consider administration, supervision, and training as three separate areas of responsibility, it is important to remember that the three cannot be totally separated. Much of your work requires you to administer, supervise, and train, all at the same time. For example, consider a motor overhaul job. As an administrator, you will schedule the job, check on the history of the motor, and ensure that the required forms and reports are submitted. As a supervisor, you will actually oversee the work and make sure it is done correctly. As a trainer, you will provide information and instruction on repair parts, rewind procedures, safety precautions, and other matters.

These administrative, supervisory, and training tasks have a direct relationship to the job at hand; namely, the overhaul of the electric motor. But, the job cannot get started unless a variety of administrative, supervisory, and training functions are performed on a continuing basis. Materials, repair parts, and tools must be available when they are needed, and jobs must be scheduled with regard to the urgency of other work. Records must be kept and required reports submitted. Also personnel must be in a continuous state of training to assume increasingly important duties and responsibilities. The only way to keep things running smoothly is to take your administrative supervisory and training responsibilities seriously.

OPERATION RESPONSIBILITIES

The engineering department administrative organization is set up to provide for proper assignment of duties and for proper supervision of personnel. However, no organization can run itself. Personnel, including yourself, are needed to ensure that all pertinent instructions are carried out and that all machinery, equipment, and electrical systems are operated following good engineering practices. Other responsibilities include the posting of instructions and safety precautions by operational equipment and ensuring that they are obeyed by all personnel. Watchstanders must be properly supervised to ensure that the entire engineering plant is operated with maximum reliability, efficiency, and safety.

In order for you to monitor and record your plant's status and performance, you need to know which engineering records and reports are required. Reports regarding administration, maintenance, and repair of naval ships are prescribed by directives from such authorities as the Type Commander, Naval Ship Systems Command (NAVSEA) and Chief of Naval Operations (CNO). These records must be accurate and up to date following current instructions.

As an EM1 or EMC, you will have new supervisory duties that will require you to have a greater knowledge of engineering records and administrative procedures. Supervisory duties and responsibilities require a knowledge of engineering records as well as inspections, administrative procedures, training, preventive maintenance, and repair procedures.

Information on the most common engineering records and reports is given in this chapter. These standard forms are prepared by the various systems commands and CNO. The forms are for issue to forces afloat and can be obtained as indicated in the *Navy Stock List of Publications and Forms*, NAVSUP 2002. Since these forms are revised periodically, personnel must be sure that the most current are obtained. When complementary forms are necessary for local use, make sure that an existing standard form will serve the purpose.

LEGAL ENGINEERING RECORDS

The Engineering Log and the Engineer's Bell Book are two legal records compiled by the engineering department. The Engineering Log is a midnight-to-midnight record of a ship's engineering department. The Engineer's Bell Book is a legal record of any order regarding change in the movement of the propellers.

ENGINEERING LOG

The Engineering Log, NAVSEA 3120/2 (fig. 1-1), and the Log Continuation Sheet, NAVSEA 3120/2, are used to record important daily events and data pertaining to an engineering department and the operation of an engineering plant. A table is provided in the log for recording the hourly average rpm (to the nearest tenth) of all shafts and the resultant speed in knots. Additional tables and spaces are provided for recording information as listed below.

1. Name of the ship
2. Date
3. Ship's draft and displacement (upon getting under way and anchoring or mooring)
4. Total engine miles steamed for the day and the distance traveled through water
5. Number of days out of dock
6. Amount of fuel, water, and lubricating oil on hand, received and expended
7. Location or route of the ship
8. Remarks relating to important events

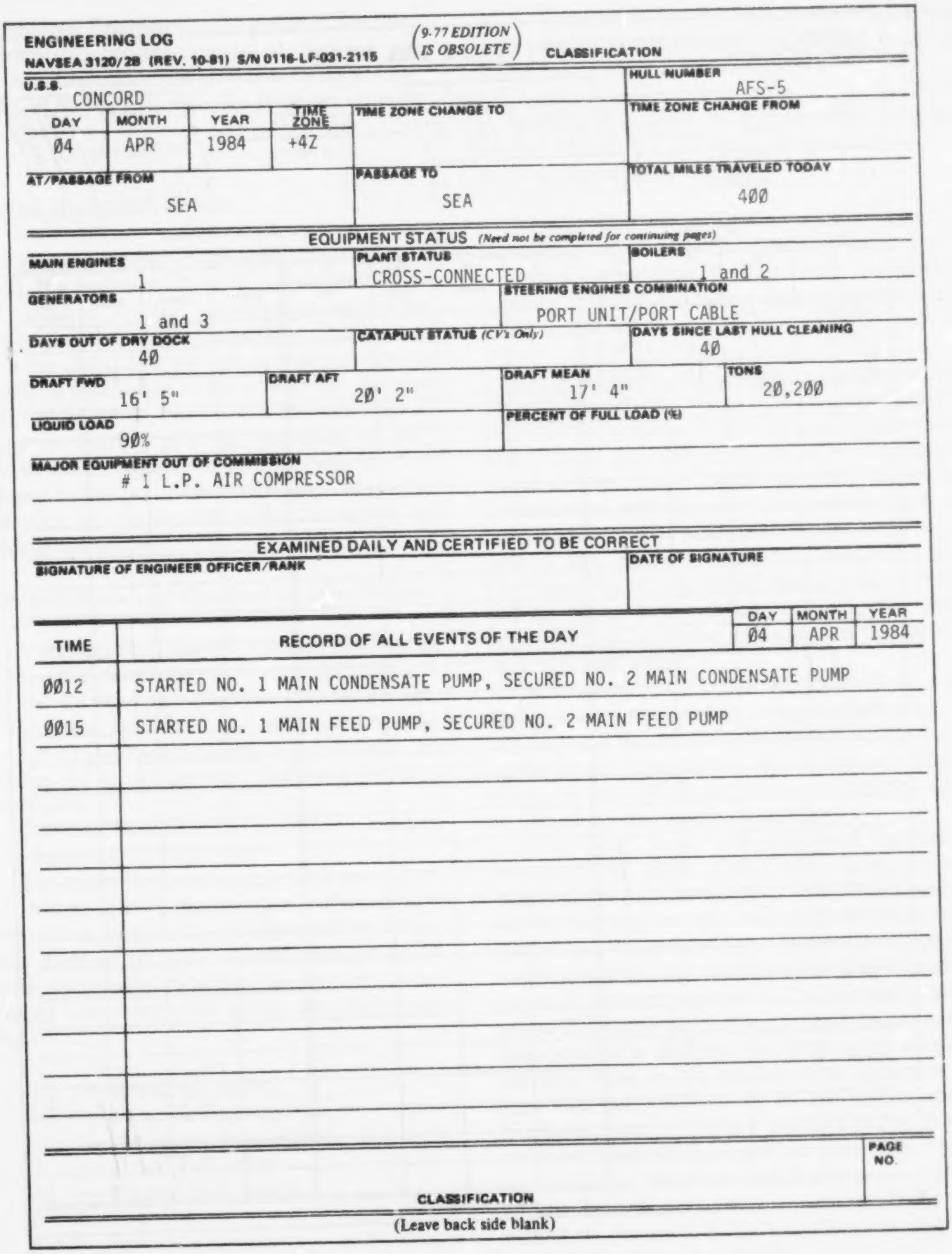
Remarks written in the Engineering Log must include (1) boilers in use, (2) engine combination in use, (3) major speed changes (such as 1/3, 2/3, standard, and full), (4) all injuries to personnel occurring within the department, (5) casualties occurring to material under the responsibility of the engineering department, and (6) such other matters as may be specified by competent authority. Each entry must be a complete statement and use standard phraseology. The type commander's directives contain other specific requirements pertaining to the remarks section of Engineering Logs for ships of the type. The engineer officer must ensure compliance with these directives.

Entries in the Engineering Log must be made following instructions given (1) on the log sheet (NAVSEA 3120/2B), (2) in chapter 10 of U.S. *Navy Regulations*, (3) in *Naval Ships' Technical Manual*, chapter 090, and (4) in directives of the type commander.

The original Engineering Log, prepared neatly and legibly in ink or pencil, is a legal record. The remarks should be prepared—and must be signed—by the engineering officer of the watch (EOOW) (underway) or the engineering department duty officer (in port). No erasures are permitted in the log. When a correction is necessary, a single line is drawn through the original entry so that the entry remains legible. The correct entry is then inserted in such a manner as to ensure clarity and legibility. Corrections, additions, or changes are made only by the person required to sign the log for the watch and are initialed on the margin of the page.

The engineer officer verifies the accuracy and completeness of all entries and signs the log daily. The commanding officer approves and signs the log on the last calendar day of each month and on the date his command is relinquished. The engineer officer should require that log sheets be submitted in sufficient time to allow his review and signature before noon of the first day following the date of the log sheet(s).

When the commanding officer (or engineer officer) directs a change or addition to the Engineering Log, the person concerned must comply unless he/she believes the proposed change or addition to be incorrect. In this event, the commanding officer (or engineer officer) enters such remarks over his signature as deemed appropriate. After the log has been signed by the commanding officer, no change is permitted without his permission or direction.



ENGINEERING LOG
NAVSEA 3120/2B (REV. 10-81) S/N 0116-LF-031-2115 (*9-77 EDITION IS OBSOLETE*) CLASSIFICATION

U.S.S. CONCORD					HULL NUMBER AFS-5
DAY	MONTH	YEAR	TIME ZONE	TIME ZONE CHANGE TO	TIME ZONE CHANGE FROM
04	APR	1984	+4Z		
AT/PASSAGE FROM SEA				PASSAGE TO SEA	TOTAL MILES TRAVELED TODAY 400

EQUIPMENT STATUS (*Need not be completed for continuing pages*)

MAIN ENGINES 1
PLANT STATUS CROSS-CONNECTED
BOILERS 1 and 2
GENERATORS 1 and 3
STEERING ENGINES COMBINATION PORT UNIT/PORT CABLE
DAYS OUT OF DRY DOCK 40
CATAPULT STATUS (*CV's Only*)
DAYS SINCE LAST HULL CLEANING 40
DRAFT FWD 16' 5"
DRAFT AFT 20' 2"
DRAFT MEAN 17' 4"
TONS 20,200
LIQUID LOAD 90%
PERCENT OF FULL LOAD (%)
MAJOR EQUIPMENT OUT OF COMMISSION # 1 L.P. AIR COMPRESSOR

EXAMINED DAILY AND CERTIFIED TO BE CORRECT

SIGNATURE OF ENGINEER OFFICER/RANK
DATE OF SIGNATURE

TIME	RECORD OF ALL EVENTS OF THE DAY — DAY 04 MONTH APR YEAR 1984
0012	STARTED NO. 1 MAIN CONDENSATE PUMP, SECURED NO. 2 MAIN CONDENSATE PUMP
0015	STARTED NO. 1 MAIN FEED PUMP, SECURED NO. 2 MAIN FEED PUMP

PAGE NO.

CLASSIFICATION

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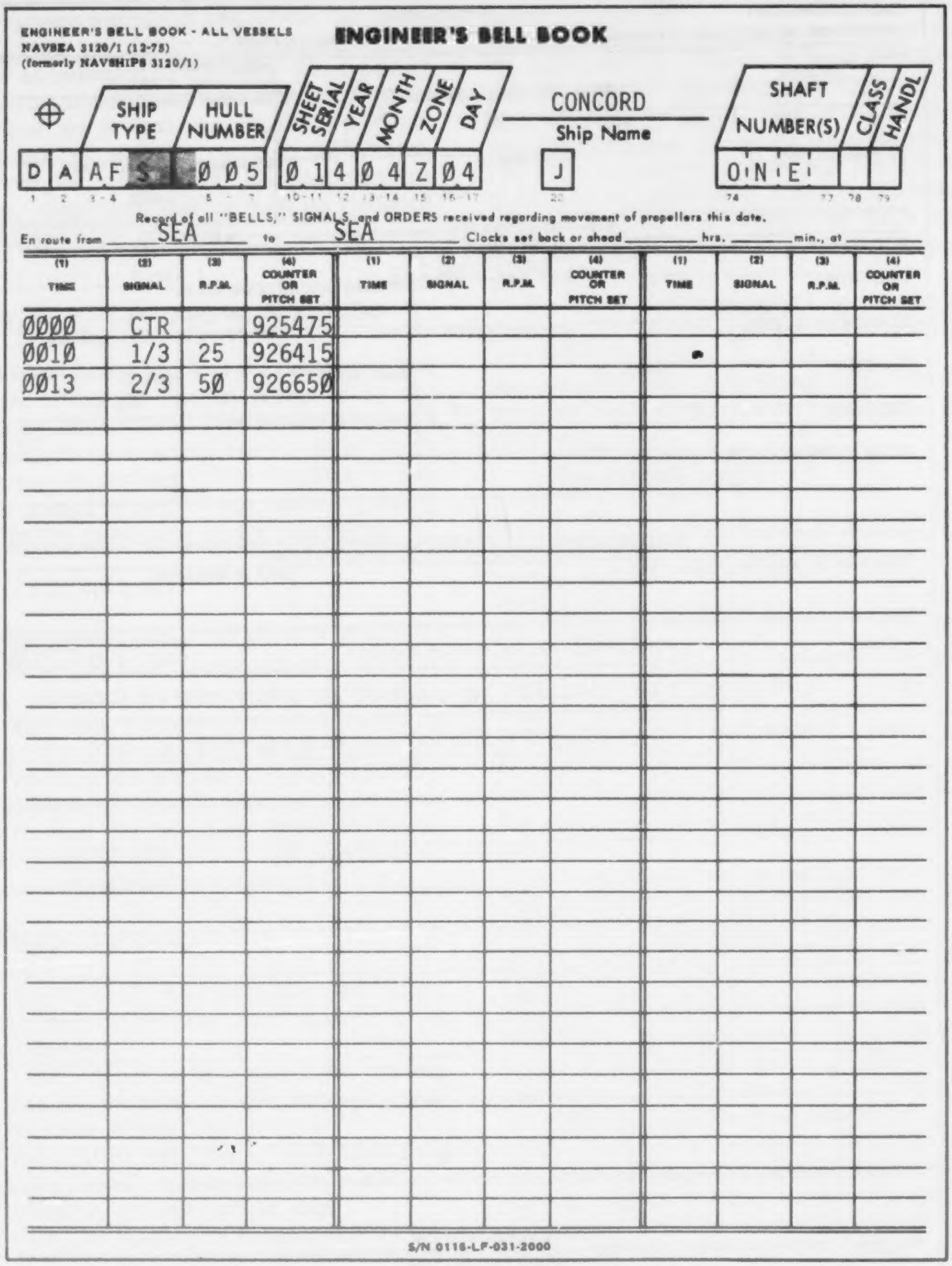
111.197

Figure 1-1.—Engineering Log—all ships.



ENGINEER'S BELL BOOK - ALL VESSELS
NAVSEA 3120/1 (12-75)
(formerly NAVSHIPS 3120/1)

ENGINEER'S BELL BOOK

⊕		SHIP TYPE	HULL NUMBER	SHEET SERIAL	YEAR	MONTH	ZONE	DAY	Ship Name		SHAFT NUMBER(S)	CLASS	HANDL
D	A	AFS	005	01	4	04	Z	04	CONCORD	J	ONE		
1	2	3-4	5-7	10-11	12	13-14	15	16-17		22	74-77	78	79

Record of all "BELLS," SIGNALS, and ORDERS received regarding movement of propellers this date.

En route from SEA to SEA Clocks set back or ahead ________ hrs. ________ min., at ________

(1) TIME	(2) SIGNAL	(3) R.P.M.	(4) COUNTER OR PITCH SET	(1) TIME	(2) SIGNAL	(3) R.P.M.	(4) COUNTER OR PITCH SET	(1) TIME	(2) SIGNAL	(3) R.P.M.	(4) COUNTER OR PITCH SET
0000	CTR		925475								
0010	1/3	25	926415								
0013	2/3	50	926650								

S/N 0116-LF-031-2000

77.230

Figure 1-2.—Engineer's Bell Book, NAVSEA 3120/1.

Completed Engineering Log sheets are filed in a post-type binder. Pages of the log are numbered consecutively with a new series of page numbers commencing with the first day of each month.

ENGINEER'S BELL BOOK

The Engineer's Bell Book, NAVSEA 3120/1 (fig. 1-2), is a record of all bells, signals, and other orders received by the throttleman regarding movement of the ship's propellers. Entries are made in the Bell Book by the throttleman (or an assistant) as soon as an order is received. Entries may be made by an assistant when the ship is entering or leaving port or engaging in any maneuver which is likely to involve numerous or rapid speed changes. This procedure allows the throttleman to devote undivided attention to answering the signals.

The Bell Book is maintained as listed below.

1. A separate bell sheet is used for each shaft each day, except where more than one shaft is controlled by the same throttle station. In this case, the same bell sheet is used to record the orders for all shafts controlled by the station. All sheets for the same date are filed together as a signal record.
2. The time of receipt of the order is recorded in column No. 1 (fig. 1-2).
3. The order received is recorded in column No. 2. Minor speed changes (generally received via revolution telegraph) are recorded by entering the number of rpm ordered. Major speed changes (normally received via engine order telegraph) are recorded using the following symbols:

1/3 —ahead 1/3 speed
2/3 —ahead 2/3 speed
I —ahead standard speed
II —ahead full speed
III —ahead flank speed
Z —stop
B 1/3—back 1/3 speed
B 2/3—back 2/3 speed
BF —back full speed
BEM —back emergency speed

4. The number of revolutions corresponding to the major speed change ordered is entered in column 3.

NOTE: When the order received is recorded as rpm in column 2 (minor speed changes), no entry is made in column 3.

5. The shaft revolution counter reading (total rpm) at the time of the speed change is recorded in column 4. The shaft revolution counter reading—as taken hourly on the hour, while under way—also is entered in column 4.

On ships and craft equipped with controllable reversible pitch propellers, the propeller pitch is recorded in column 4 in feet and fractions of feet. These are set in response to a signaled speed change, rather than the shaft revolution counter readings. The entries for astern pitch are preceded by the letter *B*. Each hour on the hour, entries are made of counter readings. This facilitates the calculation of engine miles steamed during those hours when the propeller pitch remains constant at the last value set in response to a signaled order.

Before going off watch, the EOOW signs the Bell Book on the line following the last entry for the watch. The next EOOW continues the record immediately thereafter. In machinery spaces where an EOOW is not stationed, the bell sheet is signed by the watch supervisor.

The Bell Book is maintained by bridge personnel in ships and craft equipped with controllable reversible pitch propellers and in which the engines are directly controlled from the bridge. When control is shifted to the engine room, however, the Bell Book is maintained by the engine room personnel. The last entry made in the Bell Book on the bridge indicates the time that control is shifted. The first entry made in the Bell Book in the engine room indicates the time that control is taken by the engine room. Similarly, the last entry made by the engine room personnel indicates when control is shifted to the bridge. When the Bell Book is maintained by the bridge personnel, it is signed by the officer of the deck (OOD) in the same manner as prescribed for the EOOW.

Alterations or erasures are not permitted in the Bell Book. An incorrect entry is corrected by drawing a single line through the entry and recording the correct entry on the following line. Deleted entries are initialed by the EOOW, the OOD, or the watch supervisor, as appropriate.

OPERATING RECORDS

As an EM1 or EMC, you will be responsible for the completion and submission of various operating records. These records are discussed in the following sections.

FUEL AND WATER REPORTS

The Fuel and Water Report, NAVSEA 9255/9 (figs. 1-3 and 1-4), is a report submitted daily to the commanding officer. This report indicates the amount of fuel oil and water on hand as of midnight, the previous day. The Fuel and Water Report also includes the previous day's feed and potable water performance and results of water tests. The original and one copy are submitted to the OOD in sufficient time for submission to the commanding officer or command duty officer with the 1200 reports. A copy is retained by the OOD.

MONTHLY SUMMARY

The Monthly Summary of Fuel Inventory and Steaming Hours Report is a comprehensive monthly report of engineering data. From this report the operating efficiency and general performance of the ship's engineering plant can be calculated (see fig. 1-5). Requirements for this report are contained in Fleet Commander Instructions. This report is prepared by the engineer officer and verified, as to fuel receipts, by the supply officer. It is then approved and forwarded by the commanding officer directly to the fleet commander. A copy is retained on board in the files of the engineering department. An additional copy of the report may be provided to the type commander.

AC/DC ELECTRIC PROPULSION OPERATING RECORD

The AC/DC Electric Propulsion Operating Record, NAVSEC 9622/1, is a daily record for each operating propulsion generator and motor in ships (except submarines) equipped with a.c. or d.c. electric propulsion machinery. A separate sheet is used for each shaft, except on ships with more than two generators or two motors per shaft. In this case as many sheets as needed are used.

Information is entered in the record and the remarks are written and signed by the Electrician's Mate (EM) of the watch. Accuracy is checked by the EM in charge of the electric propulsion equipment and the electrical officer. Space is provided on the record for the approval and signature of the engineer officer on a daily basis.

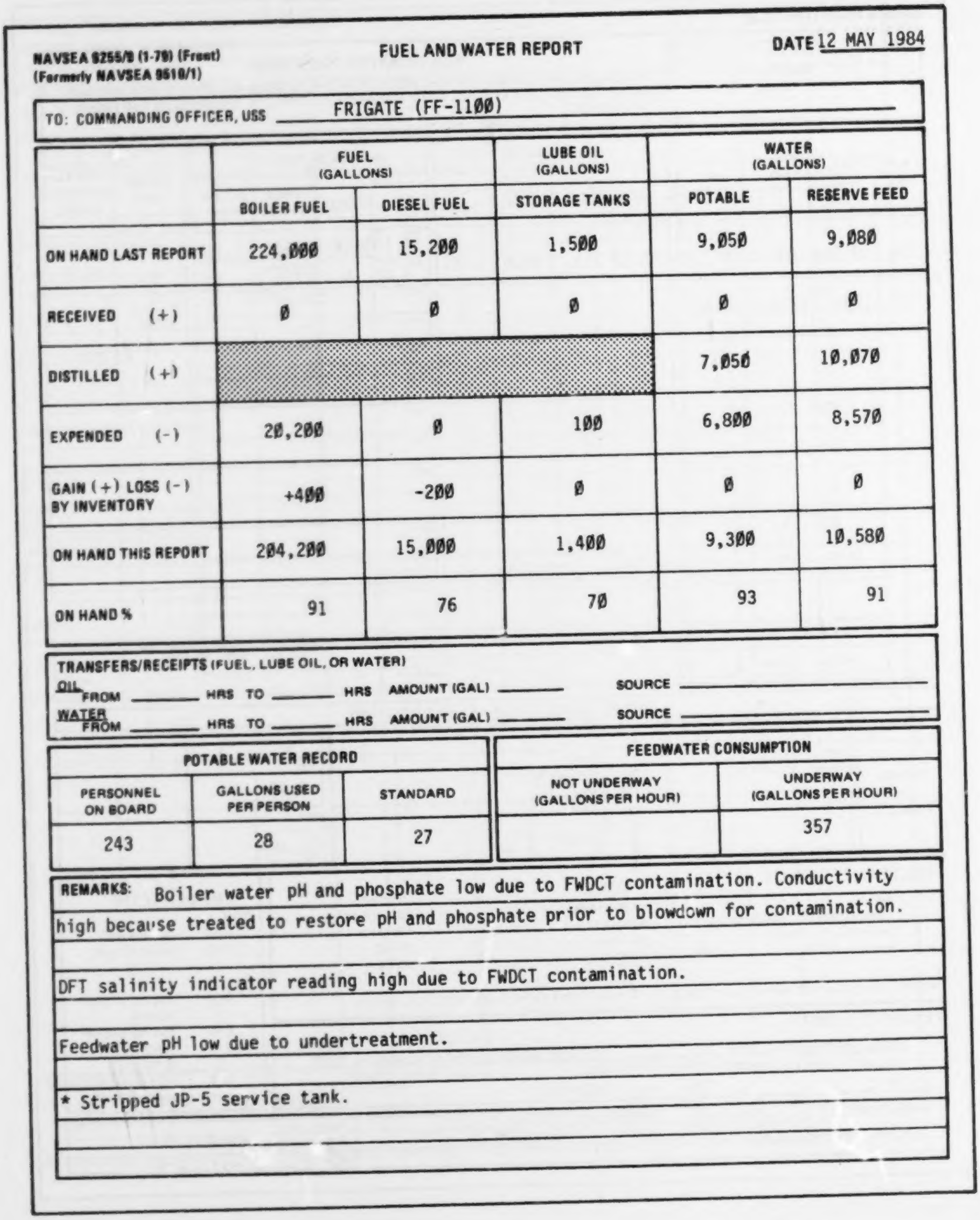
ELECTRICAL LOG

The Electrical Log, NAVSEC 9600/1 (fig. 1-6), is a complete daily record maintained for each operating ship's service and emergency generator. Entries concerning the prime movers are generally recorded by the generator watch (Machinist's Mate [MM]). Electrical information is recorded by the switchboard watch (EM) who signs the remarks for the watch.

The accuracy of the entries is checked by the EM in charge of the ship's service generators. Both the M and E division officers check the record for accuracy and any evidence of impending casualties. Each officer initials the record to indicate that it has been checked. The engineer officer notes the content and signs the record in the space provided on a daily basis.

GYROCOMPASS OPERATING RECORD

The Gyrocompass Operating Record (Gyrocompass Log) is a locally prepared, complete daily record maintained for each operating master gyrocompass. The form for the log is prepared following the type commander's directives. Columns in the log should provide space for recording the times of starting and stopping the gyrocompass, total hours of operation since delivery of the gyrocompass, and important operating data pertaining to the gyrocompass installation. The petty officer in charge of the interior communications (IC) equipment checks the accuracy of the log, and the electrical officer notes its contents on a daily basis.



NAVSEA 9255/9 (1-79) (Front)
(Formerly NAVSEA 9510/1)

FUEL AND WATER REPORT

DATE 12 MAY 1984

TO: COMMANDING OFFICER, USS FRIGATE (FF-1100)

	FUEL (GALLONS)		LUBE OIL (GALLONS)	WATER (GALLONS)	
	BOILER FUEL	DIESEL FUEL	STORAGE TANKS	POTABLE	RESERVE FEED
ON HAND LAST REPORT	224,000	15,200	1,500	9,050	9,080
RECEIVED (+)	0	0	0	0	0
DISTILLED (+)				7,050	10,070
EXPENDED (-)	20,200	0	100	6,800	8,570
GAIN (+) LOSS (-) BY INVENTORY	+400	-200	0	0	0
ON HAND THIS REPORT	204,200	15,000	1,400	9,300	10,580
ON HAND %	91	76	70	93	91

TRANSFERS/RECEIPTS (FUEL, LUBE OIL, OR WATER)
OIL FROM ________ HRS TO ________ HRS AMOUNT (GAL) ________ SOURCE ________________
WATER FROM ________ HRS TO ________ HRS AMOUNT (GAL) ________ SOURCE ________________

POTABLE WATER RECORD		
PERSONNEL ON BOARD	GALLONS USED PER PERSON	STANDARD
243	28	27

FEEDWATER CONSUMPTION	
NOT UNDERWAY (GALLONS PER HOUR)	UNDERWAY (GALLONS PER HOUR)
	357

REMARKS: Boiler water pH and phosphate low due to FWDCT contamination. Conductivity high because treated to restore pH and phosphate prior to blowdown for contamination.

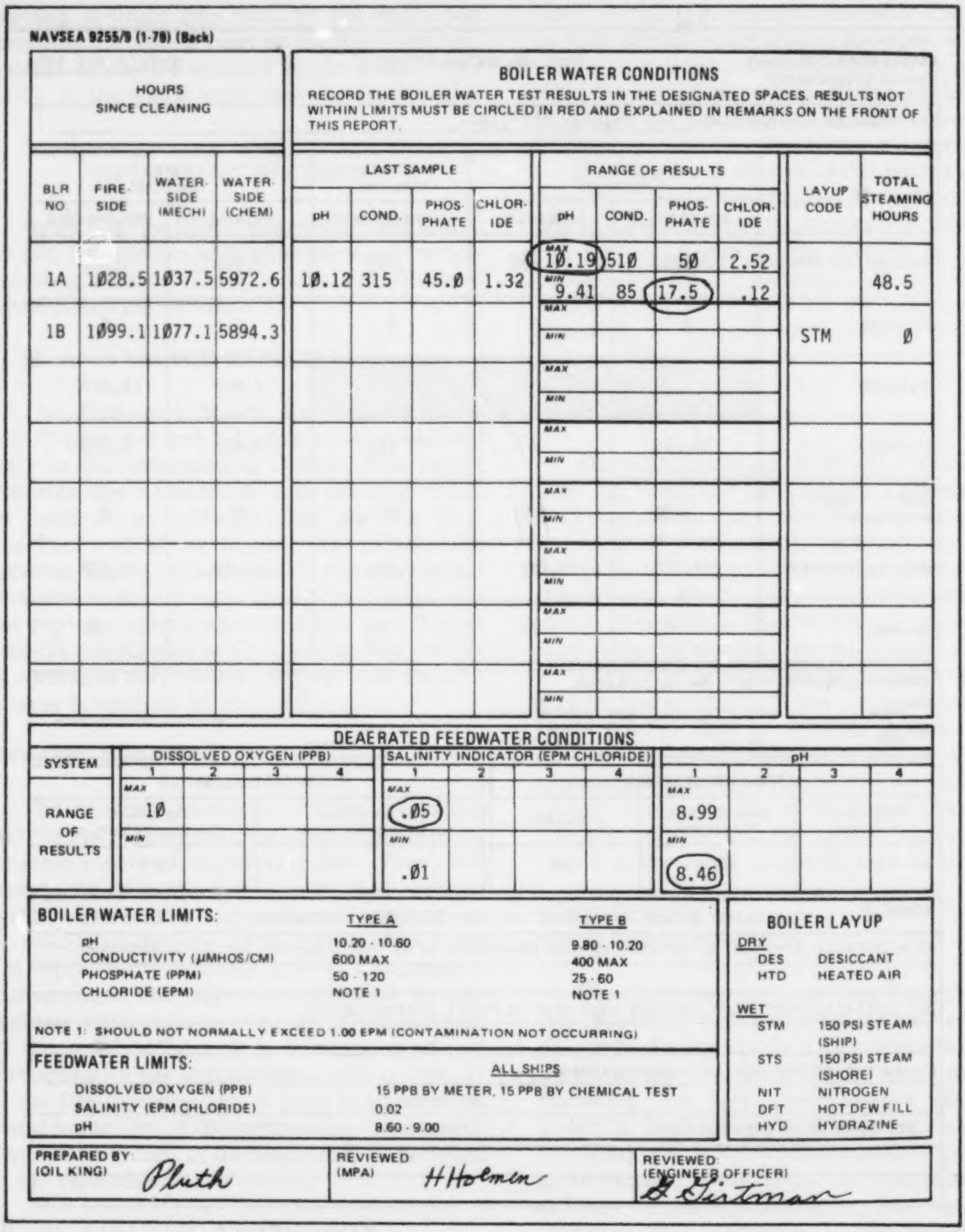
DFT salinity indicator reading high due to FWDCT contamination.

Feedwater pH low due to undertreatment.

* Stripped JP-5 service tank.

98.165

Figure 1-3.—Fuel and Water Report (Front).



NAVSEA 9255/9 (1-78) (Back)

BOILER WATER CONDITIONS

RECORD THE BOILER WATER TEST RESULTS IN THE DESIGNATED SPACES. RESULTS NOT WITHIN LIMITS MUST BE CIRCLED IN RED AND EXPLAINED IN REMARKS ON THE FRONT OF THIS REPORT.

HOURS SINCE CLEANING				LAST SAMPLE				RANGE OF RESULTS						
BLR NO.	FIRE-SIDE	WATER-SIDE (MECH)	WATER-SIDE (CHEM)	pH	COND.	PHOS-PHATE	CHLOR-IDE		pH	COND.	PHOS-PHATE	CHLOR-IDE	LAYUP CODE	TOTAL STEAMING HOURS
1A	1028.5	1037.5	5972.6	10.12	315	45.0	1.32	MAX	10.19	510	50	2.52		48.5
								MIN	9.41	85	17.5	.12		
1B	1099.1	1077.1	5894.3					MAX					STM	0
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						
								MAX						
								MIN						

DEAERATED FEEDWATER CONDITIONS

SYSTEM		DISSOLVED OXYGEN (PPB)				SALINITY INDICATOR (EPM CHLORIDE)				pH			
		1	2	3	4	1	2	3	4	1	2	3	4
RANGE OF RESULTS	MAX	10				.05				8.99			
	MIN					.01				8.46			

BOILER WATER LIMITS:

	TYPE A	TYPE B
pH	10.20 - 10.60	9.80 - 10.20
CONDUCTIVITY (µMHOS/CM)	600 MAX	400 MAX
PHOSPHATE (PPM)	50 - 120	25 - 60
CHLORIDE (EPM)	NOTE 1	NOTE 1

NOTE 1: SHOULD NOT NORMALLY EXCEED 1.00 EPM (CONTAMINATION NOT OCCURRING)

FEEDWATER LIMITS:

	ALL SHIPS
DISSOLVED OXYGEN (PPB)	15 PPB BY METER, 15 PPB BY CHEMICAL TEST
SALINITY (EPM CHLORIDE)	0.02
pH	8.60 - 9.00

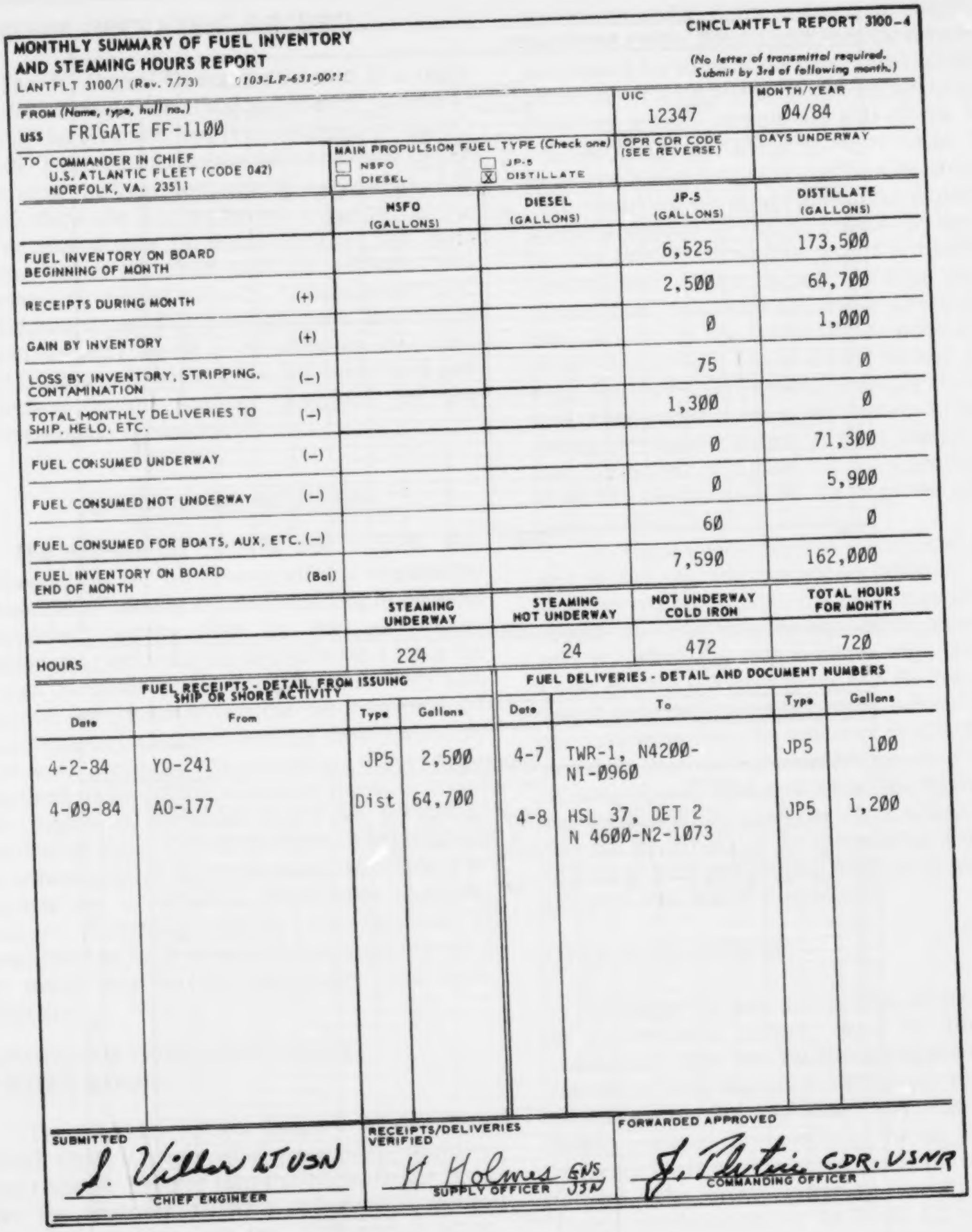
BOILER LAYUP

DRY	
DES	DESICCANT
HTD	HEATED AIR
WET	
STM	150 PSI STEAM (SHIP)
STS	150 PSI STEAM (SHORE)
NIT	NITROGEN
DFT	HOT DFW FILL
HYD	HYDRAZINE

PREPARED BY: (OIL KING)	REVIEWED: (MPA)	REVIEWED: (ENGINEER OFFICER)
Pluth	H Holmen	G Girtman

98.165

Figure 1-4.—Fuel and Water Report (Back).



MONTHLY SUMMARY OF FUEL INVENTORY AND STEAMING HOURS REPORT
LANTFLT 3100/1 (Rev. 7/73) 0103-LF-631-0011

CINCLANTFLT REPORT 3100-4
(No letter of transmittal required. Submit by 3rd of following month.)

FROM (Name, type, hull no.) USS FRIGATE FF-1100	UIC 12347	MONTH/YEAR 04/84
TO COMMANDER IN CHIEF U.S. ATLANTIC FLEET (CODE 042) NORFOLK, VA. 23511	MAIN PROPULSION FUEL TYPE (Check one) ☐ NSFO ☐ JP-5 ☐ DIESEL ☒ DISTILLATE	OPR CDR CODE (SEE REVERSE)
		DAYS UNDERWAY

		NSFO (GALLONS)	DIESEL (GALLONS)	JP-5 (GALLONS)	DISTILLATE (GALLONS)
FUEL INVENTORY ON BOARD BEGINNING OF MONTH				6,525	173,500
RECEIPTS DURING MONTH	(+)			2,500	64,700
GAIN BY INVENTORY	(+)			0	1,000
LOSS BY INVENTORY, STRIPPING, CONTAMINATION	(−)			75	0
TOTAL MONTHLY DELIVERIES TO SHIP, HELO, ETC.	(−)			1,300	0
FUEL CONSUMED UNDERWAY	(−)			0	71,300
FUEL CONSUMED NOT UNDERWAY	(−)			0	5,900
FUEL CONSUMED FOR BOATS, AUX, ETC.	(−)			60	0
FUEL INVENTORY ON BOARD END OF MONTH	(Bal)			7,590	162,000

	STEAMING UNDERWAY	STEAMING NOT UNDERWAY	NOT UNDERWAY COLD IRON	TOTAL HOURS FOR MONTH
HOURS	224	24	472	720

FUEL RECEIPTS - DETAIL FROM ISSUING SHIP OR SHORE ACTIVITY

Date	From	Type	Gallons
4-2-84	YO-241	JP5	2,500
4-09-84	AO-177	Dist	64,700

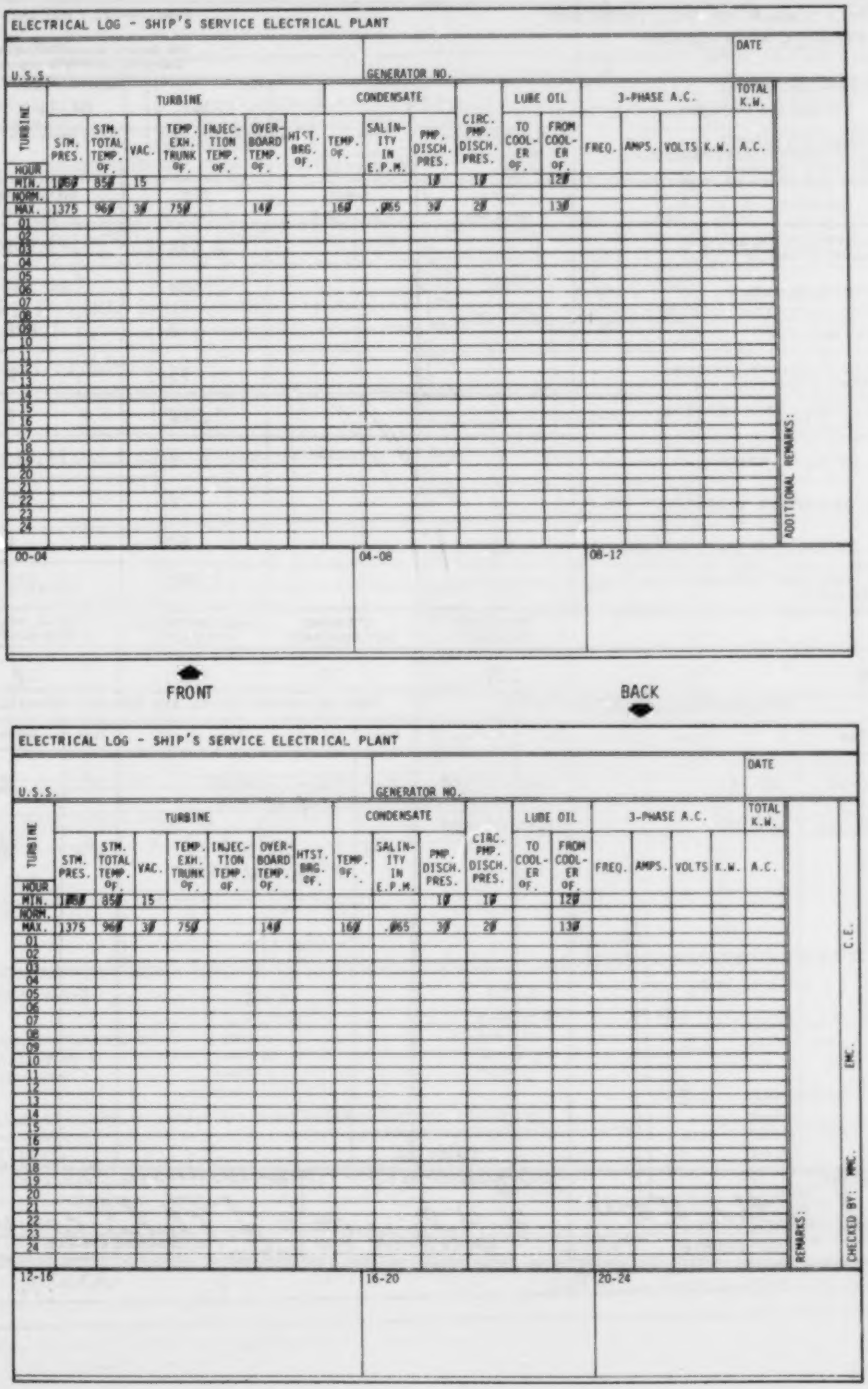
FUEL DELIVERIES - DETAIL AND DOCUMENT NUMBERS

Date	To	Type	Gallons
4-7	TWR-1, N4200-NI-0960	JP5	100
4-8	HSL 37, DET 2 N 4600-N2-1073	JP5	1,200

SUBMITTED S. Viller LT USN CHIEF ENGINEER	RECEIPTS/DELIVERIES VERIFIED H Holmes ENS USN SUPPLY OFFICER	FORWARDED APPROVED CDR. USNR COMMANDING OFFICER

147.169

Figure 1-5.—Monthly Summary of Fuel and Steaming Hours Report, CINCLANT FLT Report 3100-4.



ELECTRICAL LOG - SHIP'S SERVICE ELECTRICAL PLANT

U.S.S.
GENERATOR NO.
DATE

TURBINE	TURBINE							CONDENSATE				LUBE OIL		3-PHASE A.C.				TOTAL K.W.
HOUR	STM. PRES.	STM. TOTAL TEMP. °F.	VAC.	TEMP. EXH. TRUNK °F.	INJECTION TEMP. °F.	OVERBOARD TEMP. °F.	HIST. BRG. °F.	TEMP. °F.	SALINITY IN E.P.M.	PMP. DISCH. PRES.	CIRC. PMP. DISCH. PRES.	TO COOLER °F.	FROM COOLER °F.	FREQ.	AMPS.	VOLTS	K.W.	A.C.
MIN.	1000	850	15							10	10		120					
NORM.																		
MAX.	1375	960	30	750		140		160	.065	30	20		130					
01																		
02																		
03																		
04																		
05																		
06																		
07																		
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18																		
19																		
20																		
21																		
22																		
23																		
24																		

ADDITIONAL REMARKS:

00-04	04-08	08-12

FRONT

BACK

ELECTRICAL LOG - SHIP'S SERVICE ELECTRICAL PLANT

U.S.S.
GENERATOR NO.
DATE

TURBINE	TURBINE							CONDENSATE				LUBE OIL		3-PHASE A.C.				TOTAL K.W.
HOUR	STM. PRES.	STM. TOTAL TEMP. °F.	VAC.	TEMP. EXH. TRUNK °F.	INJECTION TEMP. °F.	OVERBOARD TEMP. °F.	HIST. BRG. °F.	TEMP. °F.	SALINITY IN E.P.M.	PMP. DISCH. PRES.	CIRC. PMP. DISCH. PRES.	TO COOLER °F.	FROM COOLER °F.	FREQ.	AMPS.	VOLTS	K.W.	A.C.
MIN.	1000	850	15							10	10		120					
NORM.																		
MAX.	1375	960	30	750		140		160	.065	30	20		130					
01																		
02																		
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23																		
24																		

REMARKS:

CHECKED BY: MMC. EMC. C.E.

12-16	16-20	20-24

114.64

Figure 1-6.—Electrical Log—Ship's Service Electric Plant.

IC ROOM OPERATING RECORD

The IC Room Operating Record is a daily record of major electrical equipment in operation in the IC room and is maintained by the IC watch. The form for the record is prepared locally following the type commander's directives. On small ships the Gyrocompass Log and the IC room record may be maintained on the same form. Important data such as voltages and currents of major units of IC equipment (IC switchboard, telephone switchboard, and motor generator sets) should be recorded on the form. The IC Room Operating Record is checked and approved in the manner described for the Gyrocompass Operating Record.

ADDITIONAL RECORDS

The engineering records and reports discussed in this section serve to inform responsible personnel of coming events (including impending casualties), supply data for the analysis of equipment performance, and provide a basis for design comparison and improvement. They also provide information for the improvement of maintenance techniques and the development of new work methods. The records are those papers required to be compiled and retained on board (in original or duplicate form) for prescribed periods of time. This is primarily for reference in administrative and operational matters. The reports are of either a onetime or recurring nature. Recurring reports are required at prescribed or set intervals. Onetime reports need be made only on the occurrence of a given situation.

ENGINEER OFFICER'S NIGHT ORDER BOOK

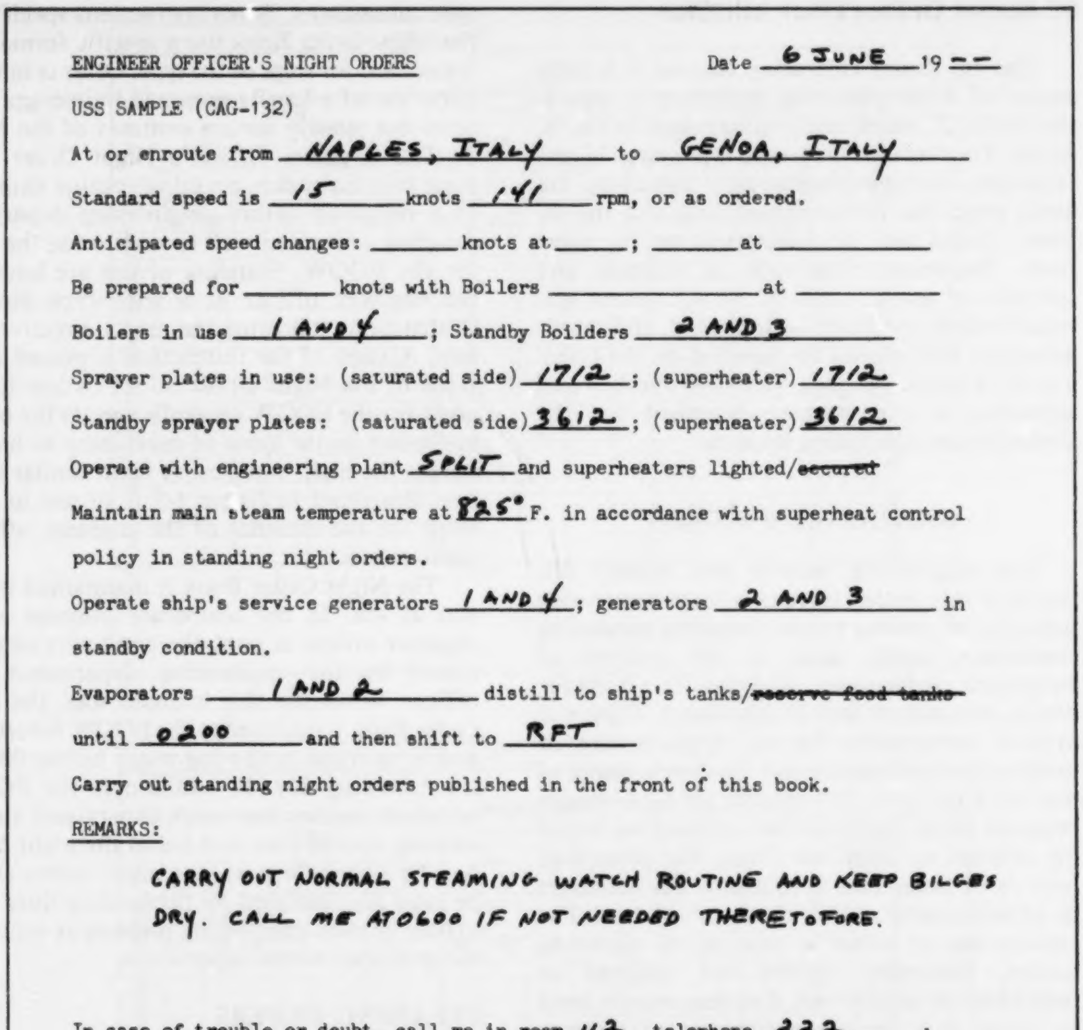
The engineer officer keeps a Night Order Book which is preserved as a part of the engineering records. Entered into the Night Order Book are the engineer officer's orders with respect to (1) operation of the engineering plant, (2) any special orders or precautions concerning the speed and operation of the main engines, and (3) all other orders for the night for the EOOW. The Night Order Book is prepared and maintained following instructions issued by the type commander. Some instructions specify that the Night Order Book use a specific format that is standard for ships of the type. Other commands allow use of a locally prepared (mimeographed) form but specify certain contents of the book.

The Engineer Officer's Night Order Book must contain orders covering routine situations of a recurring nature (engineering department standing orders) as well as orders for the night for the EOOW. Standing orders are issued by the engineer officer as a letter-type directive (instruction) following the ship's directives system. A copy of the instruction is posted in the front of the Night Order Book. Orders for the night for the EOOW generally specify the boilers and other major items of machinery to be used during the night watches. A form similar to the one illustrated in figure 1-7 is in use in some ships for the issuance of the engineer officer's night orders.

The Night Order Book is maintained in port and at sea. In the temporary absence of the engineer officer in port, the book may be maintained by the engineering department duty officer. When the ship is under way, the Night Order Book is delivered to the EOOW before 2000 and is returned to the log room before 0800 of the following day. In addition to the EOOW, principal engineering watch supervisors and the oil king should read and initial the night orders for the watch. In port, the night orders should be read and initialed by the leading duty petty officer of each engineering division as well as by the principal watch supervisors.

STEAMING ORDERS

Steaming Orders are written orders issued by the engineer officer. These list the major machinery units and readiness requirements of the engineering department based upon the time set for getting the ship under way. Generally, a locally prepared form similar to the one illustrated in figure 1-8 is used for issuance of the Steaming Orders. The orders normally specify (1) the engine combinations to be used, (2) times for lighting fires and cutting-in boilers, (3) times for warming up and testing main engines, (4) times for starting and paralleling Ship's service generators, (5) standard speed, and (6) EOOW and principal watch supervisors. Early posting



ENGINEER OFFICER'S NIGHT ORDERS Date 6 JUNE 19--

USS SAMPLE (CAG-132)

At or enroute from NAPLES, ITALY to GENOA, ITALY

Standard speed is 15 knots 141 rpm, or as ordered.

Anticipated speed changes: ____ knots at ____; ____ at ____

Be prepared for ____ knots with Boilers ____ at ____

Boilers in use 1 AND 4; Standby Boilders 2 AND 3

Sprayer plates in use: (saturated side) 1712; (superheater) 1712

Standby sprayer plates: (saturated side) 3612; (superheater) 3612

Operate with engineering plant SPLIT and superheaters lighted/~~secured~~

Maintain main steam temperature at 825° F. in accordance with superheat control policy in standing night orders.

Operate ship's service generators 1 AND 4; generators 2 AND 3 in standby condition.

Evaporators 1 AND 2 distill to ship's tanks/~~reserve feed tanks~~ until 0200 and then shift to RFT

Carry out standing night orders published in the front of this book.

REMARKS:

CARRY OUT NORMAL STEAMING WATCH ROUTINE AND KEEP BILGES DRY. CALL ME AT 0600 IF NOT NEEDED THERETOFORE.

In case of trouble or doubt, call me in room 112, telephone 222;

and LT. CORLEY in room 118, telephone 236

INITIALS

20-24 ____ ____ ____

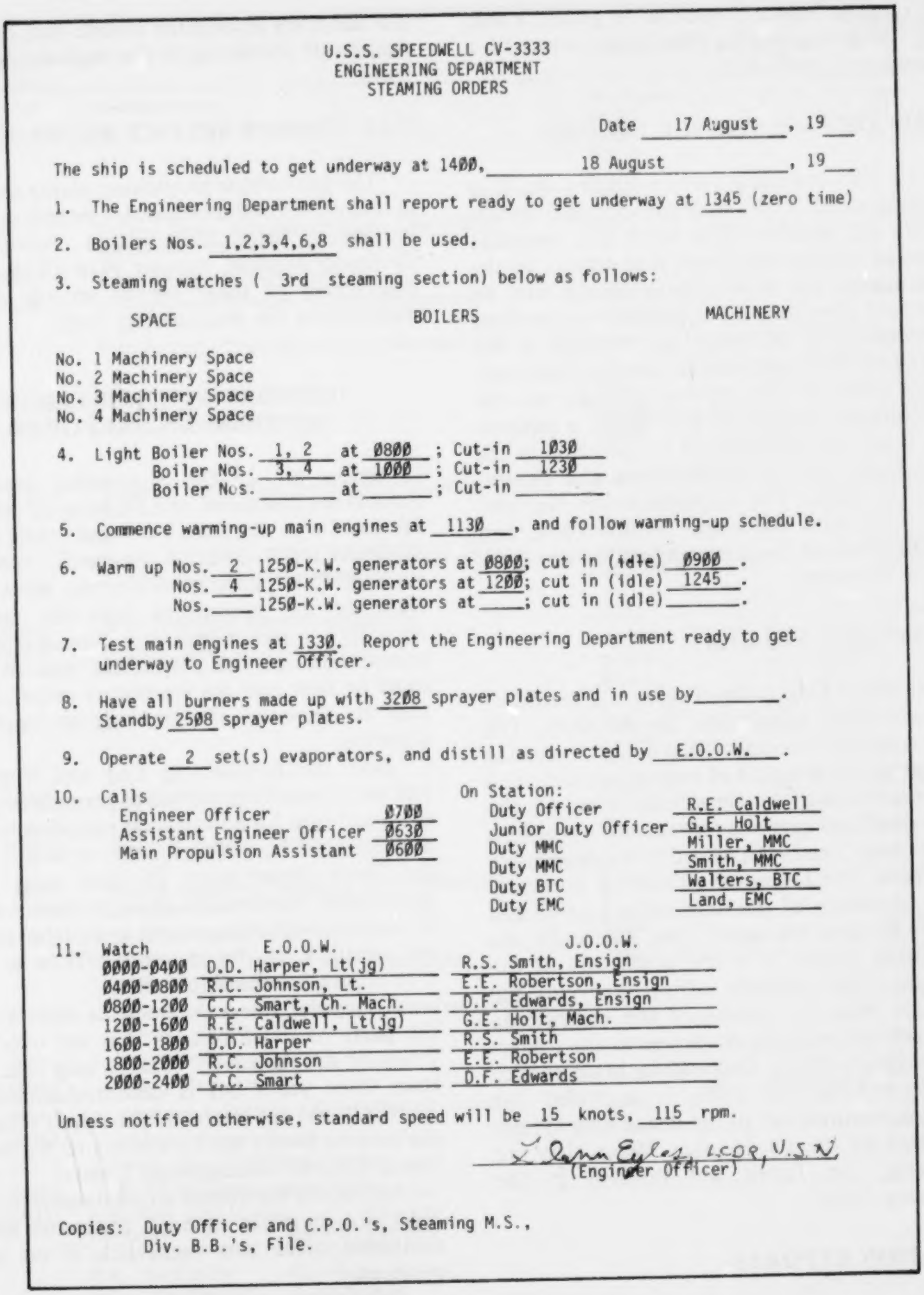
00-04 ____ ____ ____

04-08 ____ ____ ____

E. S. Savage, LCDR, USN
Engineer Officer

114.13

Figure 1-7.—Engineer Officer's Night Orders (sample).



U.S.S. SPEEDWELL CV-3333
ENGINEERING DEPARTMENT
STEAMING ORDERS

Date 17 August, 19__

The ship is scheduled to get underway at 1400, 18 August, 19__

1. The Engineering Department shall report ready to get underway at 1345 (zero time)

2. Boilers Nos. 1,2,3,4,6,8 shall be used.

3. Steaming watches (3rd steaming section) below as follows:

SPACE	BOILERS	MACHINERY
No. 1 Machinery Space		
No. 2 Machinery Space		
No. 3 Machinery Space		
No. 4 Machinery Space		

4. Light Boiler Nos. 1, 2 at 0800 ; Cut-in 1030
Boiler Nos. 3, 4 at 1000 ; Cut-in 1230
Boiler Nos. ________ at _______ ; Cut-in ________

5. Commence warming-up main engines at 1130, and follow warming-up schedule.

6. Warm up Nos. 2 1250-K.W. generators at 0800; cut in (idle) 0900.
Nos. 4 1250-K.W. generators at 1200; cut in (idle) 1245.
Nos. ____ 1250-K.W. generators at ____; cut in (idle) _______.

7. Test main engines at 1330. Report the Engineering Department ready to get underway to Engineer Officer.

8. Have all burners made up with 3208 sprayer plates and in use by ________.
Standby 2508 sprayer plates.

9. Operate 2 set(s) evaporators, and distill as directed by E.O.O.W.

10.

Calls		On Station:	
Engineer Officer	0700	Duty Officer	R.E. Caldwell
Assistant Engineer Officer	0630	Junior Duty Officer	G.E. Holt
Main Propulsion Assistant	0600	Duty MMC	Miller, MMC
		Duty MMC	Smith, MMC
		Duty BTC	Walters, BTC
		Duty EMC	Land, EMC

11.

Watch	E.O.O.W.	J.O.O.W.
0000-0400	D.D. Harper, Lt(jg)	R.S. Smith, Ensign
0400-0800	R.C. Johnson, Lt.	E.E. Robertson, Ensign
0800-1200	C.C. Smart, Ch. Mach.	D.F. Edwards, Ensign
1200-1600	R.E. Caldwell, Lt(jg)	G.E. Holt, Mach.
1600-1800	D.D. Harper	R.S. Smith
1800-2000	R.C. Johnson	E.E. Robertson
2000-2400	C.C. Smart	D.F. Edwards

Unless notified otherwise, standard speed will be 15 knots, 115 rpm.

L. Iann Eyles, LCDR, U.S.N.
(Engineer Officer)

Copies: Duty Officer and C.P.O.'s, Steaming M.S.,
Div. B.B.'s, File.

114.14

Figure 1-8.—Steaming Orders (sample).

of Steaming Orders is essential to getting a ship with a large engineering plant under way with a minimum of confusion.

GYROCOMPASS SERVICE RECORD

The Gyrocompass Service Record Book is furnished the ship with each gyrocompass (except the Mk 22) installed. The book is a complete record of inspections, tests, and repairs to the gyrocompass and must always remain with its associated gyrocompass. Complete instructions for maintaining the record are outlined in the front of the book and must be carefully followed. In the event of loss of—or damage to—the Gyrocompass Service Record Book, a replacement book can be obtained as indicated in the *Navy Stock List of Publications and Forms*, NAVSUP 2002. The requisition for the new book must show the mark, modification, and serial numbers of the gyrocompass for which the book is intended.

DEGAUSSING FOLDER

The ship's Degaussing Folder is a record of the degaussing installation in the ship. The folder contains (1) a description of the degaussing installation; (2) a record of inspection, tests, and repairs performed by repair activities; (3) the values of all coil currents for the ship's positions and headings'; and (4) a record of the degaussing range runs. The Degaussing Folder is necessary to the operation of the degaussing system and must be safeguarded against loss. Generally, the Degaussing Folder is in the possession of the navigator. The engineer officer provides the navigator with the names of the engineering personnel who will require access to the folder.

The Ship's Force Degaussing Maintenance Record, NAVSHIPS 1009, is provided for recording maintenance of the degaussing system performed by the ship's force. When they are completed, the forms are inserted in the degaussing folder.

SITUATION REPORTS

Situation reports (SITREPS) are onetime reports required in certain situations. Figure 1-9 is a summary of onetime reports (not previously described) pertaining to the engineering department.

GAS TURBINE SERVICE RECORDS

The gas turbine propulsion plants are unique in that service and maintenance records are similar to aircraft propulsion plants. *Naval Ships' Technical Manual*, chapter 9416 (0234), gives a description of these service records and full instructions for maintaining them.

DISPOSAL OF ENGINEERING RECORDS AND REPORTS

Before any of the engineering department records are destroyed, the *Disposal of Navy and Marine Corps Records*, USN and USNS vessels, SECNAVINST P5212.5 (revised), should be studied. This publication informs ships of the Navy of the procedures used for disposing records. For each department aboard ship, these instructions list the permanent records which must be kept and the temporary records which may be disposed of following an established schedule.

Both the Engineering Log and Engineer's Bell Book must be preserved as permanent records on board ship for a three-year period unless they are requested by a Naval Court or Board, or by the Navy Department. In such case, copies (preferably photostatic) of such sheets or parts of these records that are sent away from the ship are certified by the engineer officer as being true copies for the ship's files.

At regular intervals, such as each quarter, the parts of those records that are over three years old are destroyed. When a ship that is less than three years old is decommissioned, the current books are retained. If a ship is scrapped, the current books are forwarded to the nearest Naval Records Management Center.

All reports forwarded to, and received from, NAVSEA or other superior command may be destroyed when two years old, if no longer required.

Only those reports which are required or serve a specified purpose should be maintained on board ship. However, any report or record

REPORT NUMBER NAVSEA	TITLE	FORMAT	FREQ CODE	REFERENCE NSTM CHAPTER
9070-2	Docking Report	NAVSEA 9070/1 9070/2 9070/3 9070/4 9070/5	S	Chap. 997 (9070) 094 (9080)
9000-1	Delivery Report upon Delivery of any Ship to any Government	Letter	S	094 (9080)
9880-2	Storm Damage to Ships—report of	Letter	S	100 (9110)
4710-2	Examination of Structure by Shipyards; report of	Letter or message	S	100 (9110)
4730-1	Periodic Cargo Tank Inspections & Tests (AO, AOR & AOG)	Letter	S	100 (9110)
9080-1	Report of Deep Dive	Letter	S	100 (9110)
3530-2	Magnetic Compass Table	NAVSEA 3120/4	S or every 12 mo.	252 (9240)
9291-2	Report of Solid Ballast Installation or Changes	Letter, Drawing or Sketch	S	096 (9290)
9290-1	Report of Excessive Rolling, Heeling or Pounding or Inadequate Propeller Immersion	Letter & 2 Data Sheets		096 (9290) 096 (9290)
9410-1	Main Propulsion Turbines; condition of	Letter	S	231 (9411)
9410-2	Turbine Lifting and Repair Report	NAVSEA 9410/4 9410/5 9410/6 9410/7 9410/8 9410/9	S	231 (9411)
9430-1	Bent or Cracked Shafts	Letter	S	243 (9430) 100 (9110)
9440-1	Report of Propeller Measurements	NAVSEA 420	S	245 (9440)
3960-1	Fuels & Lubricants, Testing of, by Naval Shipyards Laboratories	Letter	S	262 (9450)
9510-1	Boiler Settings on Safety Valve	Letter		221 (9510)
9500-1	Auxiliary Steam Turbines; Protection Against Excessive pressure, relief valves	Letter	S	551 (9490)
9510-6	Boiler Maintenance of Brickwork; Refractory Lining, Provision for Vibration	Letter	S	221 (9510)
9610-1	Submarine Battery Quarterly Report	NAVSEA 149	Q	223 (9623)
9620-6	Battery Water Analysis	Letter	S	223 (9623)
9620-1	Inspection of Submarine Battery Elements; report of	Letter	S	223 (9623)
9620-3	Battery Deficiency Report	Letter	S	223 (9623)
9720-5	Ammunition Handling & Stowage	Letter	S	700 (9780)
4440-4	Report of Change in Boats Status	NAVSEA 215	S	583 (9820)

*LEGEND: Frequency code letters:

D—Daily
W—Weekly
BW—Bi-Weekly
SM—Semi-Monthly
M—Monthly
BM—Bi-Monthly
Q—Quarterly
SA—Semi-Annually
A—Annually
S—Situation

Figure 1-9.—Summary of Situation Reports.

which may assist personnel in scheduling or making repairs and which will supply personnel with information which is not contained in publications or manuals should also be kept on board.

TRAINING

By the time you have reached the E-5 or E-6 level, you have acquired many skills and a large amount of theoretical knowledge. However, this does not guarantee your success as an instructor. You must be technically competent before you can teach others. However, your technical competence must be supplemented by the ability to organize information. You must also be able to present it effectively and to arouse and keep the interest of your trainees.

You will find excellent general information on how to plan, carry out, and evaluate an instructional program in *Military Requirements for PO 3 & 2*, NAVEDTRA 10056-E1, and in *Military Requirements for PO 1 & C*, NAVEDTRA 10057-D. Each person must be trained to perform not only as an individual but also as a member of a team. Take for example the duties of the switchboard watch standers. They are very closely related. The actions taken by one person depend in some way upon the actions taken by others. So as individuals are being trained for one specific duty, they must of necessity be learning something about the other duties.

The procedures for training a new person vary considerably. These procedures depend upon such factors as the ship's steaming schedule, the condition of the equipment, the number of experienced personnel available to assist in the training, and the amount of time that can be devoted to the training. However, you will probably begin to train a person by placing that individual with an experienced watch stander. The trainee must also be instructed in certain basic safety precautions and be specifically warned about the dangers of pushing buttons, turning knobs, or tampering with machinery. IF IN DOUBT, ASK QUESTIONS! is a good rule for the trainee.

In training personnel who have not had previous experience, remember that engine rooms and emergency diesel rooms can be a complicated and confusing place. This is especially true for someone who walks into it for the first time. A lot of equipment is crammed into a small space. Also, many complex actions are going on at once. When training new personnel, try to think back to the time when you first went into an engine room and looked at a switchboard. What aspects of the operation were most confusing to you at first? What kind of training would have made your learning easier and faster? By analyzing your own early experiences and reactions, you get an idea of what a new person may be experiencing. This will enable you to provide more effective training.

When you are training new personnel, remember that they vary widely in their methods of learning and in their rates of learning. Some people will learn most effectively if you give them an overall view of main engine operations, including a certain amount of theory, before going into the details of the hardware and the manual operations. Others will learn most effectively if they are taught some manual skills before getting too much involved with theory. Some people learn manual skills rapidly but take a long time to absorb theory. The reverse is true for others. Of course, some people learn everything slowly. Some trainees benefit from patient, almost endless repetition of information. Others may become bored and restless if you go over the same point just once too often. Remember that your efforts will be more successful if you are able to observe and allow for the individual differences that exist. Closely related to this is that you should not make snap judgments about people's abilities until they have had a chance to DEMONSTRATE them. You may be wrong if you make snap judgments on the basis of a general impression, such as appearance or the rate at which they learn when they first come to your division.

Hands-on training is considered to be best. However, the person must not be allowed to learn by trial and error; errors can be dangerous and costly. Therefore, training must be rigidly controlled and adequately supervised. Safety precautions should be taught from the very beginning and should be emphasized constantly throughout the entire training program.

TRAINING PROGRAMS

As an EM1 or EMC, you are required to establish or maintain a training program for your work center personnel. On smaller ships you might be the division officer, responsible for a number of work centers. In these programs you are required to teach the proper methods of equipment operation, repair, and safety. You should use all the materials available to you including teaching aids, such as manufacturer's technical manuals, instructions, or rate training manuals. In addition, you should know what schools are available to your workers and should try to get quotas for eligible and deserving personnel (i.e., EM A or C, or 400 Hz school).

Military Training

The aim of the military training phase of the shipboard training program is to familiarize the crew with military customs and courtesies, naval discipline (*U.S. Navy Regulations and General Orders*), military justice (*Uniform Code of Military Justice*), obligations and responsibilities of citizenship, conduct ashore in foreign countries, and related subjects. You may include some of these subjects in your indoctrination program. Your more experienced personnel also need to be reminded of certain rights, privileges, courtesies, customs, obligations, and responsibilities. Morning quarters can also be a useful period of instruction as well as for muster and inspection.

Professional Training

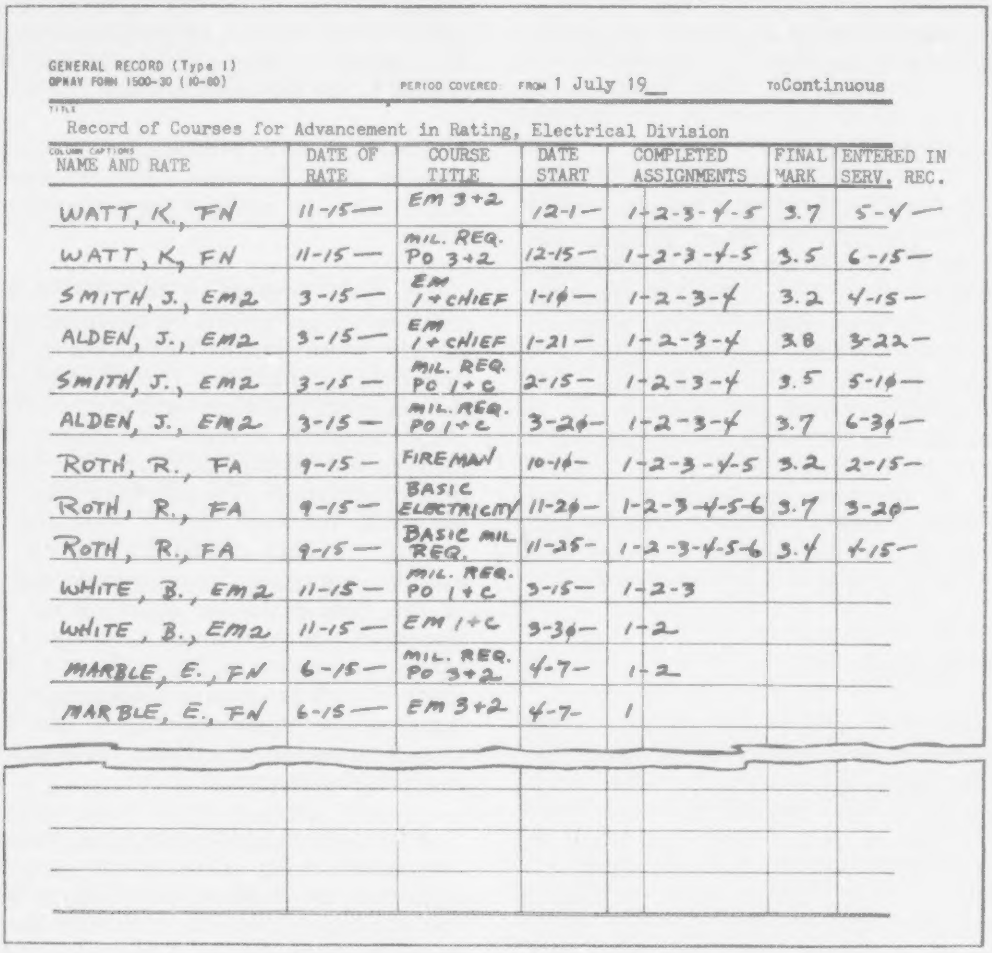
The Naval correspondence course program provides self-study training courses to assist personnel in improving their professional qualifications and increasing their general knowledge of naval science. The list of Training Manuals and Correspondence Courses, NAVEDTRA 10061 (revised), contains procedures for ordering courses, course titles, NAVEDTRA numbers, and brief descriptions of the courses available. You should encourage your personnel to participate in the self-study courses.

Development of professional knowledge and physical skills increases their efficiency and helps them to qualify for advancement in rating.

BUPERS Instruction 1430.16A establishes mandatory requirements for advancement which include the satisfactory completion of specified rate training manuals. The *Bibliography for Advancement Examination Study*, NAVEDTRA 10052 (revised), identifies mandatory training manuals and recommended reading material for the various ratings. The mandatory rate training manual(s) for each rate is indicated by an asterisk (*). Each mandatory training manual may be completed by successful completion of the correspondence course based on the mandatory training manual. A Record of Courses for Advancement (similar to the one shown in fig. 1-10) will assist you in determining (1) the status of self-study training in the division and (2) the personnel qualified for recommendation for advancement.

Personnel under your supervision should be recommended for advancement only if and when they are in all respects fully qualified to hold the higher rate. Advancements should not be made in the nature of rewards for faithful or extended service or simply because the minimum service requirements have been fulfilled. Advancing personnel (or recommending personnel for a change in rating) to positions for which they are not fully qualified is poor policy.

Over the years, the Navy has endeavored to be selective in accepting personnel for enlistment, and the vast majority of enlisted personnel should be competent in the performance of their duties. The average Navy enlisted person is one whom any commanding officer would welcome. To make the enlisted performance evaluation system successful, assume that each command has an average crew. The proportion of individuals who exceed or fall below the average in performance, then would be about the same for



GENERAL RECORD (Type I)
OPNAV FORM 1500-30 (10-60)

PERIOD COVERED: FROM 1 July 19__ TO Continuous

TITLE
Record of Courses for Advancement in Rating, Electrical Division

COLUMN CAPTIONS

NAME AND RATE	DATE OF RATE	COURSE TITLE	DATE START	COMPLETED ASSIGNMENTS	FINAL MARK	ENTERED IN SERV. REC.
WATT, K., FN	11-15—	EM 3+2	12-1—	1-2-3-4-5	3.7	5-4—
WATT, K, FN	11-15—	MIL. REQ. PO 3+2	12-15—	1-2-3-4-5	3.5	6-15—
SMITH, J., EM2	3-15—	EM 1+CHIEF	1-10—	1-2-3-4	3.2	4-15—
ALDEN, J., EM2	3-15—	EM 1+CHIEF	1-21—	1-2-3-4	3.8	3-22—
SMITH, J., EM2	3-15—	MIL. REQ. PO 1+C	2-15—	1-2-3-4	3.5	5-10—
ALDEN, J., EM2	3-15—	MIL. REQ. PO 1+C	3-20—	1-2-3-4	3.7	6-30—
ROTH, R., FA	9-15—	FIREMAN	10-10—	1-2-3-4-5	3.2	2-15—
ROTH, R., FA	9-15—	BASIC ELECTRICITY	11-20—	1-2-3-4-5-6	3.7	3-20—
ROTH, R., FA	9-15—	BASIC MIL. REQ.	11-25—	1-2-3-4-5-6	3.4	4-15—
WHITE, B., EM2	11-15—	MIL. REQ. PO 1+C	3-15—	1-2-3		
WHITE, B., EM2	11-15—	EM 1+C	3-30—	1-2		
MARBLE, E., FN	6-15—	MIL. REQ. PO 3+2	4-7—	1-2		
MARBLE, E., FN	6-15—	EM 3+2	4-7—	1		

24.1A

Figure 1-10.—A sample record of courses for advancement.

all commands. For the overall good of the Navy and in the interest of the great majority of enlisted personnel, evaluations under the enlisted performance evaluation system should be related in general to the average crew concept.

One of the primary purposes of the evaluation system is to permit the commanding officer to influence positively the advancement opportunities of the individuals of the command. To make the performance factor in the final multiple for advancement effective, evaluations must differentiate between individuals. Credit is then given according to demonstrated performance. Should all individuals be evaluated too highly, the ability to assist those individuals who are in fact outstanding will be reduced.

Enlisted evaluation reports should be completely frank. Outstanding performance should be reported, and evaluations should also be thoroughly objective in reporting an individual's shortcomings. Knowledge of such shortcomings can be vital in the selection of personnel for duty assignment. A detailed discussion of the enlisted evaluation system is contained in the *Military Personnel Manual.*

Service wide examinations for advancement in rating are conducted on a semiannual basis for pay grades E-4 through E-6, and annually for pay grade E-7. Examinations for pay grades E-8 and E-9 have been dropped. These examinations are prepared by senior petty officers in each rating at the Naval Education and Training Program Development Center, Pensacola, Florida. The examination for advancement in a rating is based on the professional requirements of the rate and rating involved.

Apprenticeship Training

The Apprenticeship Program for Electrical Repairers, (DOT Code 829.281-014) was started in 1976. It was established under the authority of the Secretary of the Navy and Secretary of Labor as the National Apprentice Standards for the United States Navy. The purpose of establishing the National Apprenticeship Standards for the United States Navy was to provide general policy and guidance to commanding officers responsible for normal and on-the-job rating training. It was also designed to develop and register with the National Office of the Bureau of Apprenticeship and Training, U.S. Department of Labor, programs of apprenticeship for active-duty naval personnel in occupations closely related and applicable to the needs and requirements of private industry. In many instances, current Navy training and on-the-job experience will, if properly documented, satisfy the requirements of private industry for the training of apprentices in nationally recognized occupations.

The ultimate objective of the National Apprenticeship Standards of the United States Navy is to provide registered certification of the rate training of Navy personnel and to achieve recognition of the Navy person equal to his/her civilian counterpart. Registration with the Bureau of Apprenticeship and Training (BAT), U.S. Department of Labor, for naval occupational specialities is mutually beneficial to the Navy, to the individual, and to private industry. Acceptance of Navy apprentices and skilled craftsmen by private industry will enhance employment opportunities for Navy Veterans, motivate Navy personnel to advance within their rating while on active duty, and provide a source of registered skilled personnel to meet national manpower requirements. You should ensure that your personnel are familiar with this program. Processing of applications for registration is administered by the Branch Head, EM A School SSC, NTC, Great Lakes.

TRAINING RECORDS

Scheduling training requires the careful attention of the training officer, departmental heads, and division officers in order to minimize conflict in activities and to ensure that time allotted is used to the best advantage. The only justification for a record of training is that it indicates to those responsible for training how much has been accomplished and how much remains to be done. Records should be kept to an absolute minimum consistent with needs. The true measurement of an effective training program is performance, and the basic objective of any record should be to assist in accomplishing this in the simplest way possible. When possible, the same forms used to schedule planned training should be used to record completed training.

Group

The schedules and records listed below, together with the description of the preparation and use, are presented as an example of a system which will facilitate careful planning, orderly administration, and effective control of the training program. As work center supervisor or division officer, you will be required to either maintain or submit information for most of the following training forms:

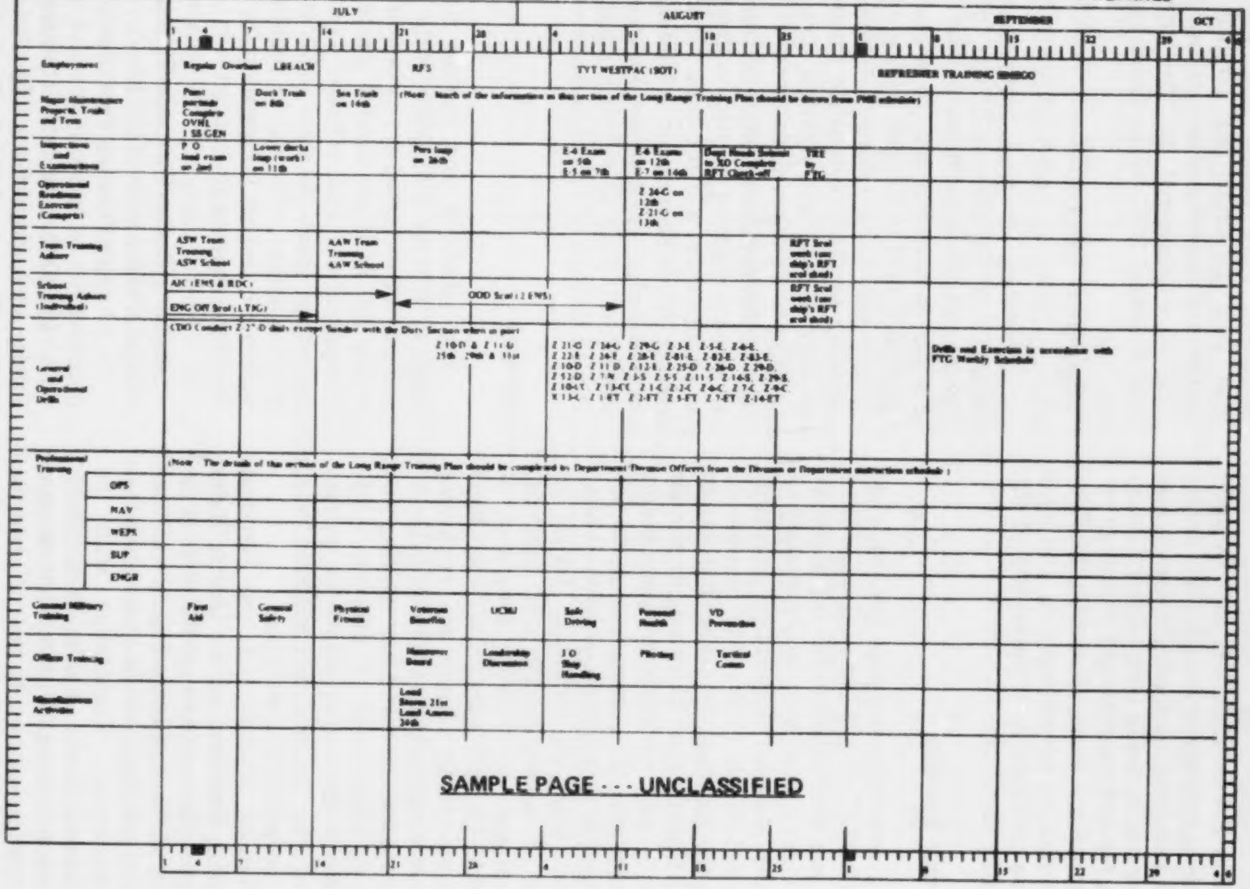
1. Long-Range/Quarterly Training Plan (fig. 1-11), OPNAV Form 3120.1A.
2. Monthly Training Plan (fig. 1-12). Locally prepared.
3. TYCOM Required Training Exercises, Trials, and Inspections (fig. 1-13), General Record (Type 1), OPNAV Form 1500-30.
4. Division Training Schedule (fig. 1-14), General Record (Type III), OPNAV Form 1500-32.

LONG RANGE TRAINING PLAN

FIRST QUARTER AFTER REGULAR OVERHAUL, JULY (CALENDAR YEAR) - SEPTEMBER (CALENDAR YEAR)

CONFIDENTIAL (WHEN FILLED IN)

PREPARED



	JULY					AUGUST				SEPTEMBER				OCT
	1 4	7	14	21	28	4	11	18	25	1	8	15	22	29 6
Employment	Regular Overhaul LBEACH			RFS		TYT WESTPAC (SOT)				REFRESHER TRAINING SDIEGO				
Major Maintenance Projects, Trials and Tests	Paint portside Complete OVHL 1 SS GEN	Dock Trials on 8th	Sea Trials on 14th	(Note: Much of the information in this section of the Long Range Training Plan should be drawn from PMS schedule)										
Inspections and Examinations	P O lead exam on 2nd	Lower decks insp (work) on 11th		Pers insp on 26th		E-4 Exam on 5th E-5 on 7th	E-6 Exam on 12th E-7 on 14th	Dept Heads Submit to XO Complete RFT Check-off	TRE by FTG					
Operational Readiness Exercises (Competx)							Z 24-G on 12th Z 21-G on 13th							
Team Training Ashore	ASW Team Training ASW School		AAW Team Training AAW School						RFT Scol work (see ship's RFT scol sked)					
School Training Ashore (Individual)	AIC (ENS & RDC) → ENG Off Scol (LTJG) →			← OOD Scol (2 ENS) →					RFT Scol work (see ship's RFT scol sked)					
General and Operational Drills	(DO Conduct Z 2"-D daily except Sunday with the Duty Section when in port)				Z 10-D & Z 11-D 25th 29th & 31st	Z 21-G Z 24-G Z 29-G Z 3-E Z 5-E, Z 6-E, Z 22-E Z 24-E Z 28-E Z 01-E Z 02-E Z 03-E, Z 10-D Z 11-D Z 12-E Z 25-D Z 26-D Z 29-D, Z 52-D Z 7-N Z 3-S Z 5-S Z 11-S Z 14-S, Z 29-S, Z 10-CC Z 13-CC Z 1-C Z 2-C Z 6-C Z 7-C Z 9-C, X 13-C Z 1-ET Z 2-ET Z 5-ET Z 7-ET Z 14-ET					Drills and Exercises in accordance with FTG Weekly Schedule			
Professional Training	(Note: The details of this section of the Long Range Training Plan should be completed by Department/Division Officers from the Division or Department instruction schedule.)													
OPS														
NAV														
WEPS														
SUP														
ENGR														
General Military Training	First Aid	General Safety	Physical Fitness	Veterans Benefits	UCMJ	Safe Driving	Personal Health	VD Prevention						
Officer Training				Manpower Board	Leadership Discussion	J O Ship Handling	Piloting	Tactical Comm						
Miscellaneous Activities				Load Stores 21st Load Ammo 24th										

SAMPLE PAGE - - - UNCLASSIFIED

24.1B

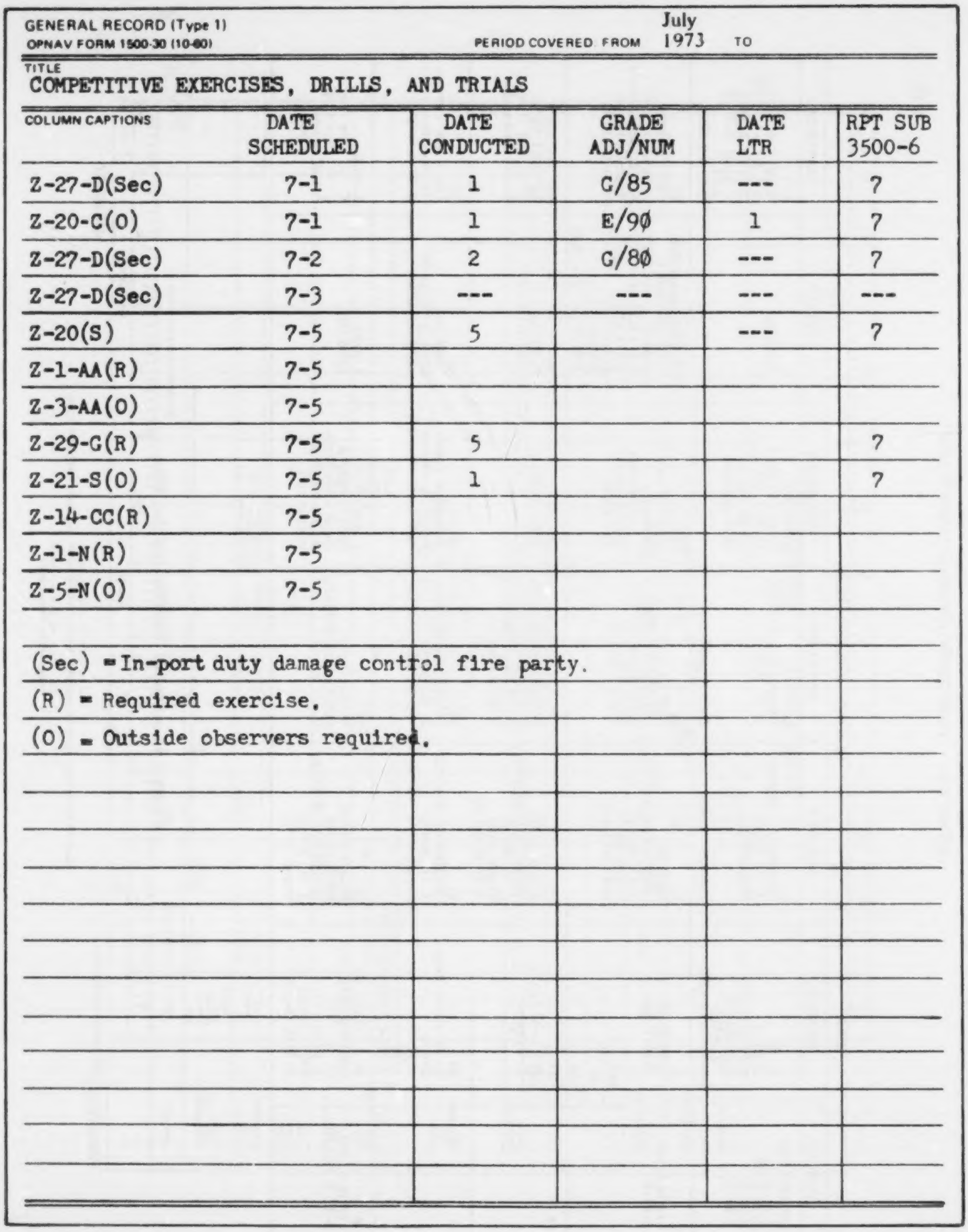
Figure 1-11.—Long-Range/Quarterly Training Plan.

JULY MONTHLY TRAINING PLAN 1973

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
OPPORTUNE: Z-26-S (R) Z-28-S (O) Z-29-S Z-13-CC	1 G. Q. Z-10-D NBC Lecture Intelligence Briefing UNREP: 3 DER	2 DIVISIONAL SCHOOL J. O. School Cryto Drill UNREP: 2 MSO	3 DIVISIONAL SCHOOL J. O. School INREP An Thoi	4 Hand grenade & small arms training all day for Deck and Ops	5 Field Day	6 G. Q. Battle Prob Z-6-D Z-11-S (R) Z-10-D Z-14-S Z-24-D Z-27-D Z-52-D Z-111-E (R)
7 Arrive Subic Z-27-D	8 Z-20-C (O) Z-27-D (Sec I)	9 GMT III DIVISIONAL SCHOOL J. O. School Crypto Drill Z-27-D (Sec II)	10 GMT III DIVISIONAL SCHOOL J. O. School Z-27-D (Sec III)	11 Lookouts lecture (Steaming Watches) Z-27-D (Sec I) PAY DAY	12 0500 Depart SUB G. Q. Gun Shoot Z-20-S Z-14-CC (R) Z-1-AA(R) Z-1-N(R) Z-3-AA(O) Z-5-N(O) Z-29-G (R) Z-110-E (R) Z-21-S (O) Z-1-E(R)	13 SF-1, 6-M (R) for all departments GQLT NBC Lecture Training Board Z-27-D (Night)
14	15 Mil/Lead Exams E-3 Exams	16 Arrive YOKO DIVISIONAL SCHOOL J. O. School Crypto Drill Z-27-D (Sec II)	17 DIVISIONAL SCHOOL J. O. School Blood Donations Z-27-D (Sec III)	18 Z-27-D (Sec I)	19 Field Day Z-27-D (Sec II)	20 DEPART YOKO C. O. Pers Insp. C. O. Zone Insp.
21	22 G. Q. Battle Prob. Z-6-D Z-10-D Z-24-D Z-27-D	23 DIVISIONAL SCHOOL J. O. School Crypto Drill	24 DIVISIONAL SCHOOL J. O. School	25 Telephone Talker Drill (GQ talkers) PAY DAY	26 Field Day SF-2, 5-M (R) for all departments	27 GQLT NBC Lecture Training Board Z-27-D (Night)
28 Arrive PEARL Z-27-D (Sec III)	29 COMSERVPAC visit G. Q. Z-10-D NBC Lecture Z-27-D (Sec I)	30 Depart PEARL DC Lectures DIVISIONAL SCHOOL J. O. School Crypto Drill	31 DC Lectures DIVISIONAL SCHOOL J. O. School	1 AUG Hand grenade & small arms training for Supply & Engineering	2 AUG Field Day	3 AUG C. O. Zone Insp. C. O. Pers Insp. 5 AUG Arrive SFRAN

114.77

Figure 1-12.—Sample Monthly Training Plan.



GENERAL RECORD (Type 1)
OPNAV FORM 1500-30 (10-60)
PERIOD COVERED FROM July 1973 TO

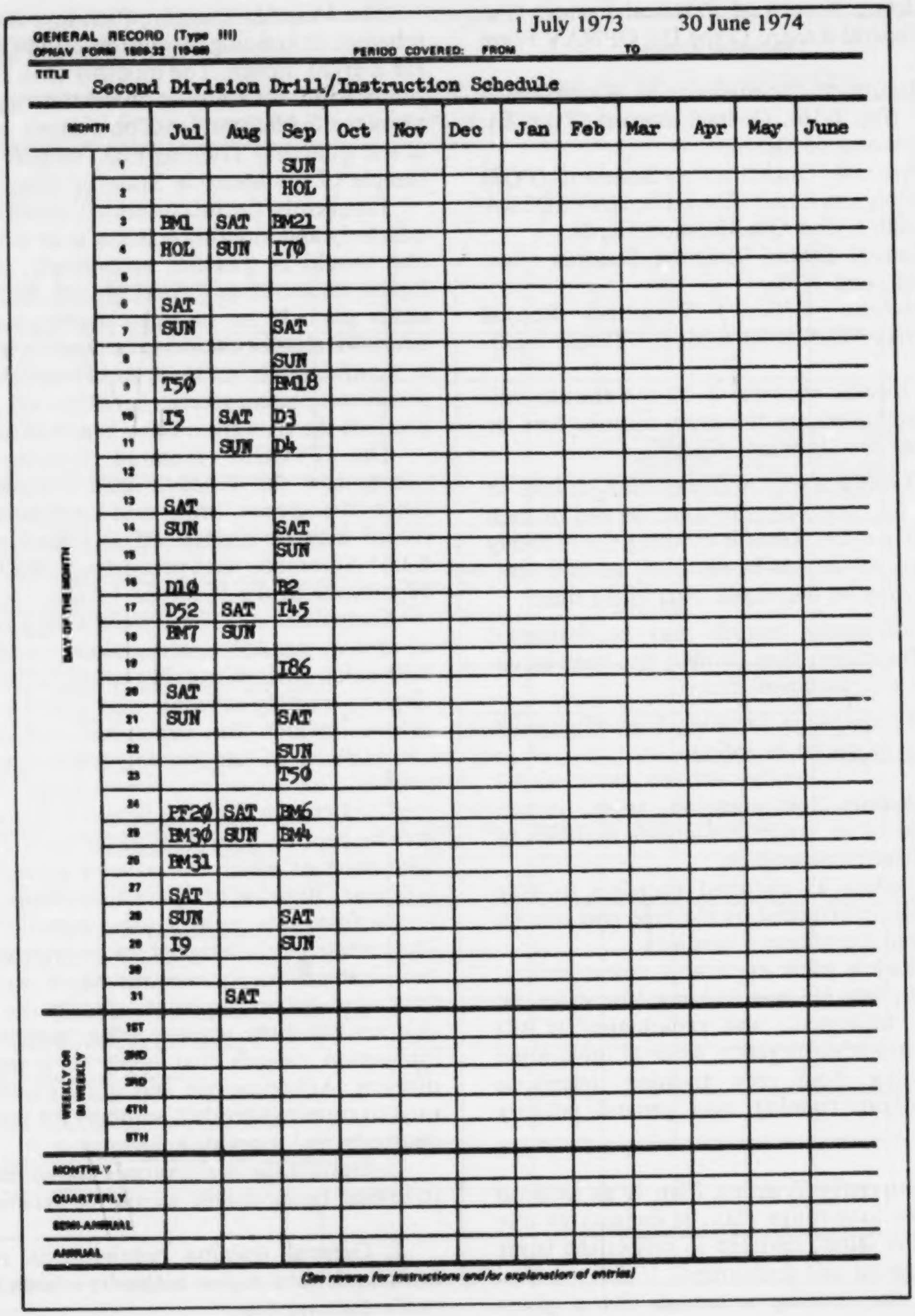
TITLE
COMPETITIVE EXERCISES, DRILLS, AND TRIALS

COLUMN CAPTIONS	DATE SCHEDULED	DATE CONDUCTED	GRADE ADJ/NUM	DATE LTR	RPT SUB 3500-6
Z-27-D(Sec)	7-1	1	G/85	---	7
Z-20-C(O)	7-1	1	E/90	1	7
Z-27-D(Sec)	7-2	2	G/80	---	7
Z-27-D(Sec)	7-3	---	---	---	---
Z-20(S)	7-5	5		---	7
Z-1-AA(R)	7-5				
Z-3-AA(O)	7-5				
Z-29-G(R)	7-5	5			7
Z-21-S(O)	7-5	1			7
Z-14-CC(R)	7-5				
Z-1-N(R)	7-5				
Z-5-N(O)	7-5				

(Sec) = In-port duty damage control fire party.
(R) = Required exercise.
(O) = Outside observers required.

114.78

Figure 1-13.—TYCOM Required Training Exercises, Trials, and Inspections.



GENERAL RECORD (Type III)
OPNAV FORM 1000-32 (10-68)
PERIOD COVERED: FROM 1 July 1973 TO 30 June 1974

TITLE Second Division Drill/Instruction Schedule

MONTH		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
DAY OF THE MONTH	1			SUN									
	2			HOL									
	3	BM1	SAT	BM21									
	4	HOL	SUN	I70									
	5												
	6	SAT											
	7	SUN		SAT									
	8			SUN									
	9	T50		BM18									
	10	I5	SAT	D3									
	11		SUN	D4									
	12												
	13	SAT											
	14	SUN		SAT									
	15			SUN									
	16	D10		B2									
	17	D52	SAT	I45									
	18	BM7	SUN										
	19			I86									
	20	SAT											
	21	SUN		SAT									
	22			SUN									
	23			T50									
	24	PF20	SAT	BM6									
	25	BM30	SUN	BM4									
	26	BM31											
	27	SAT											
	28	SUN		SAT									
	29	I9		SUN									
	30												
	31		SAT										
WEEKLY OR BI WEEKLY	1ST												
	2ND												
	3RD												
	4TH												
	5TH												
MONTHLY													
QUARTERLY													
SEMI-ANNUAL													
ANNUAL													

(See reverse for instructions and/or explanation of entries)

114.79

Figure 1-14.—Division Training Schedule.

5. Group Record of Practical Factors (fig. 1-15), General Record (Type II), OPNAV Form 1500-31.
6. Record of Qualification at Watch/Battle Stations (fig. 1-16), General Record (Type II), OPNAV Form 1500-31.
7. Personnel Qualifications Standards (PQS) Record Progress Chart (fig. 1-17), NAVEDTRA Form 1500/1, and Qualification Cards.
8. Formal School Training Records (figs. 1-18, 1-19, and 1-20).
9. Division Officer's Personnel Record Form, NAVPERS 1070/6 (figs. 1-21 and 1-22).

The specific records to be maintained will be as prescribed by the type commanders or individual commanding officers.

The Long-Range/Quarterly Plan should be retained for ninety days beyond the end of each competitive cycle. Records covering the Monthly Training Plan should be retained for one year. Records may be destroyed after these times.

All continuous records may be destroyed when information they contain has been transferred to a replacement record.

The Long-Range Training Plan (fig. 1-11) should be prepared as follows:

1. Schedule fleet exercises, trials, inspections, and other major evolutions required by type or fleet commanders.
2. Schedule all required exercises in kind and frequency required by the type commander to maintain Condition 1 readiness.
3. Schedule other applicable unit exercises.
4. Schedule all unit training (for example, chemical, biological, and radiological (CBR) lectures, counterinsurgency, security orientation and training, boat crew training, telephone talker/lookout training, and general military training).

The Quarterly Training Plan is an integral part of the long-range plan. It consists of one sheet of the latter, updated to reflect the latest information on unit deployment. It also specifies in detail the training intentions for a given quarter. The plan may be prepared by filling in the details of the subsequent quarter of the Long-Range Training Plan.

The Monthly Training Plan lays out a daily schedule of training, evolutions, and operations for a given month. The monthly plan should be prepared by the training board showing all unit training, evolutions, and operations scheduled in the Quarterly Training Plan. (Figure 1-12 is a sample of the Monthly Training Plan.)

Frequently the information contained in the quarterly and monthly training plan is classified and should be guarded accordingly. Secret or higher information should not be disclosed on either plan. If the highest classification of the operational information to be shown on the plan is Confidential, its protection and disclosure should not present security problems which would preclude the crew from being kept well informed.

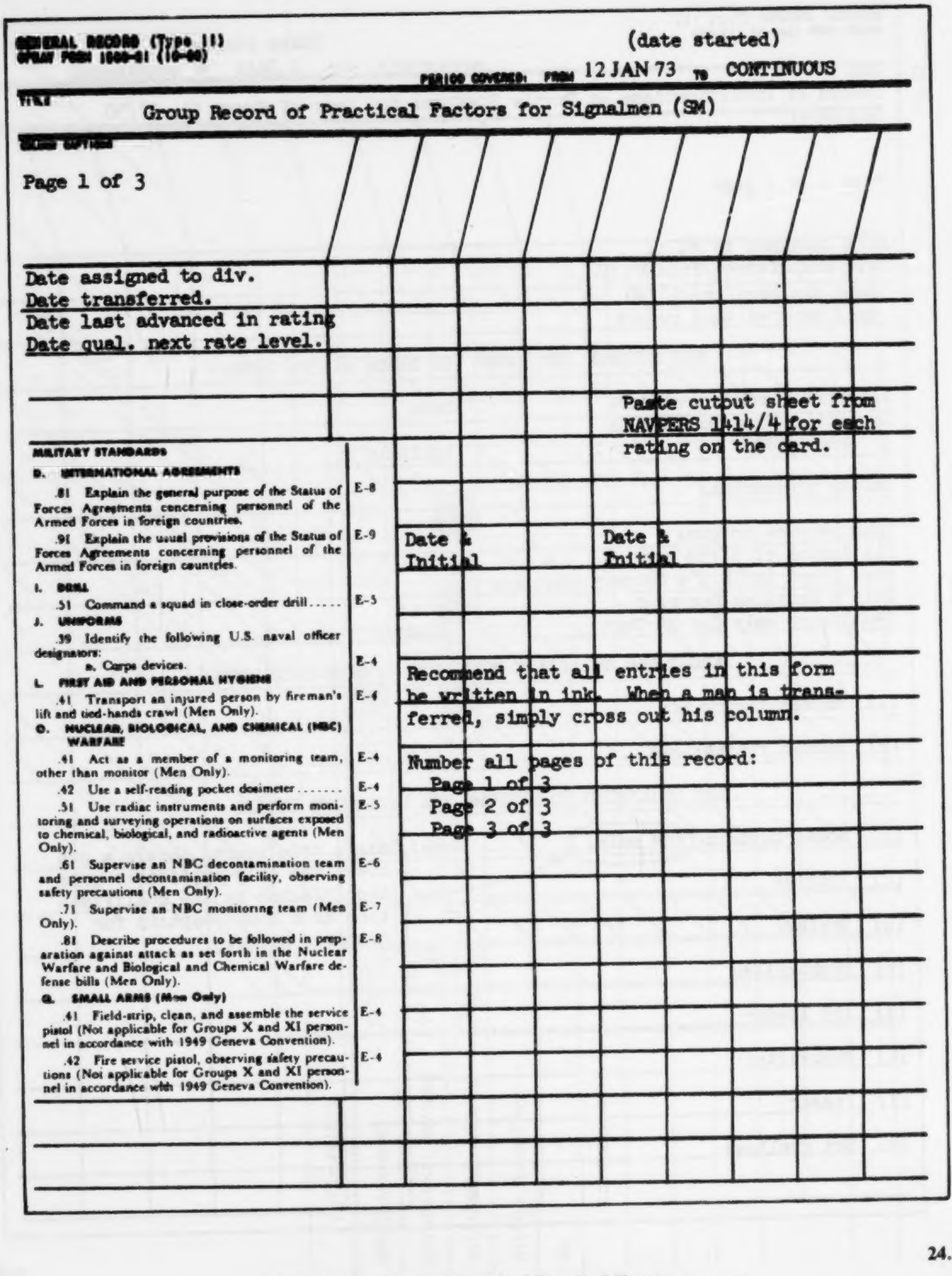
The TYCOM required training record summarizes the schedule and completion of required exercises, drills, and inspections. (This record may be maintained as shown in figure 1-13.) Automatic data processing printouts may be substituted for the Type I form.

Each division officer should keep a record of all operational drills, team training periods, and instruction periods peculiar to the division. The division training schedule may also be used to reserve periods for supervised self-study of advancement-in-rate training or correspondence courses.

The Division Training Schedule (figure 1-14) may be kept on both sides of OPNAV 1500/32, each sheet of which can cover a period of one full year. Because of space limitations, entries on the front side must be abbreviated or coded. The reverse side is designed for entering information, instructions, or remarks which explain the data recorded on the front side. On the reverse side are listed the various drills, exercises, and instruction periods that apply to a particular division. Abbreviations and serial numbers are used to supply short drill numbers for use on the quarterly and monthly schedules.

In drafting the division training schedule, the following requirements should be satisfied:

1. General training requirements of type commander and higher authority schedule in the unit's training plan
2. General orientation, indoctrination, and qualification requirements
3. PARs required for advancement



GENERAL RECORD (Type II)
OPNAV FORM 1000-21 (10-60)

(date started)
PERIOD COVERED: FROM 12 JAN 73 TO CONTINUOUS

TITLE
Group Record of Practical Factors for Signalmen (SM)

COLUMN CAPTIONS
Page 1 of 3

Date assigned to div.
Date transferred.
Date last advanced in rating
Date qual. next rate level.

Paste cutout sheet from NAVPERS 1414/4 for each rating on the card.

MILITARY STANDARDS	
D. INTERNATIONAL AGREEMENTS	
.81 Explain the general purpose of the Status of Forces Agreements concerning personnel of the Armed Forces in foreign countries.	E-8
.91 Explain the usual provisions of the Status of Forces Agreements concerning personnel of the Armed Forces in foreign countries.	E-9
I. DRILL	
.51 Command a squad in close-order drill.....	E-5
J. UNIFORMS	
.39 Identify the following U.S. naval officer designators: a. Corps devices.	E-4
L. FIRST AID AND PERSONAL HYGIENE	
.41 Transport an injured person by fireman's lift and tied-hands crawl (Men Only).	E-4
O. NUCLEAR, BIOLOGICAL, AND CHEMICAL (NBC) WARFARE	
.41 Act as a member of a monitoring team, other than monitor (Men Only).	E-4
.42 Use a self-reading pocket dosimeter	E-4
.51 Use radiac instruments and perform monitoring and surveying operations on surfaces exposed to chemical, biological, and radioactive agents (Men Only).	E-5
.61 Supervise an NBC decontamination team and personnel decontamination facility, observing safety precautions (Men Only).	E-6
.71 Supervise an NBC monitoring team (Men Only).	E-7
.81 Describe procedures to be followed in preparation against attack as set forth in the Nuclear Warfare and Biological and Chemical Warfare defense bills (Men Only).	E-8
Q. SMALL ARMS (Men Only)	
.41 Field-strip, clean, and assemble the service pistol (Not applicable for Groups X and XI personnel in accordance with 1949 Geneva Convention).	E-4
.42 Fire service pistol, observing safety precautions (Not applicable for Groups X and XI personnel in accordance with 1949 Geneva Convention).	E-4

Date & Initial

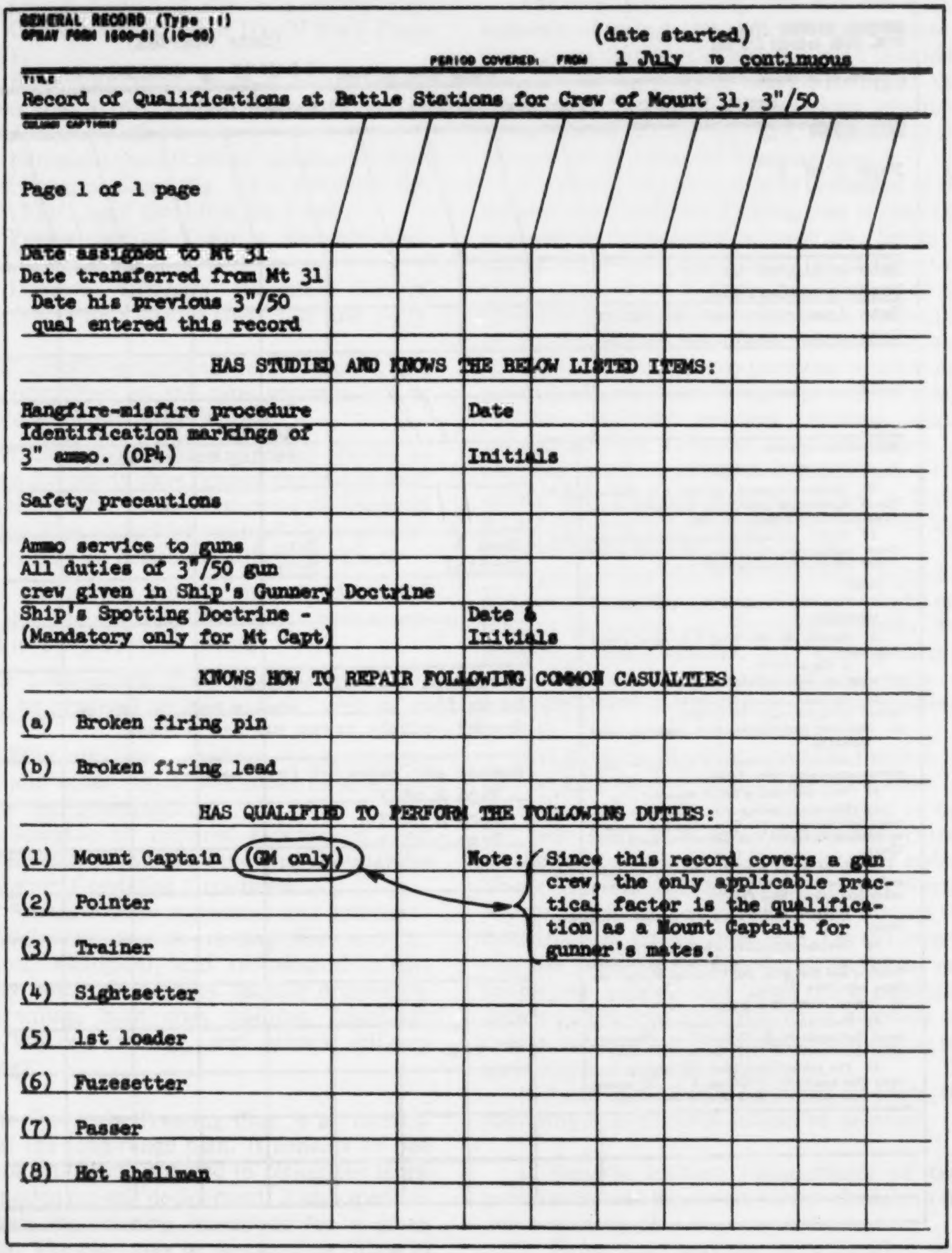
Date & Initial

Recommend that all entries in this form be written in ink. When a man is transferred, simply cross out his column.

Number all pages of this record:
Page 1 of 3
Page 2 of 3
Page 3 of 3

24.3A

Figure 1-15.—Group Record of Practical Factors.



GENERAL RECORD (Type II)
OPNAV FORM 1600-81 (10-60)

(date started)
PERIOD COVERED: FROM 1 July TO continuous

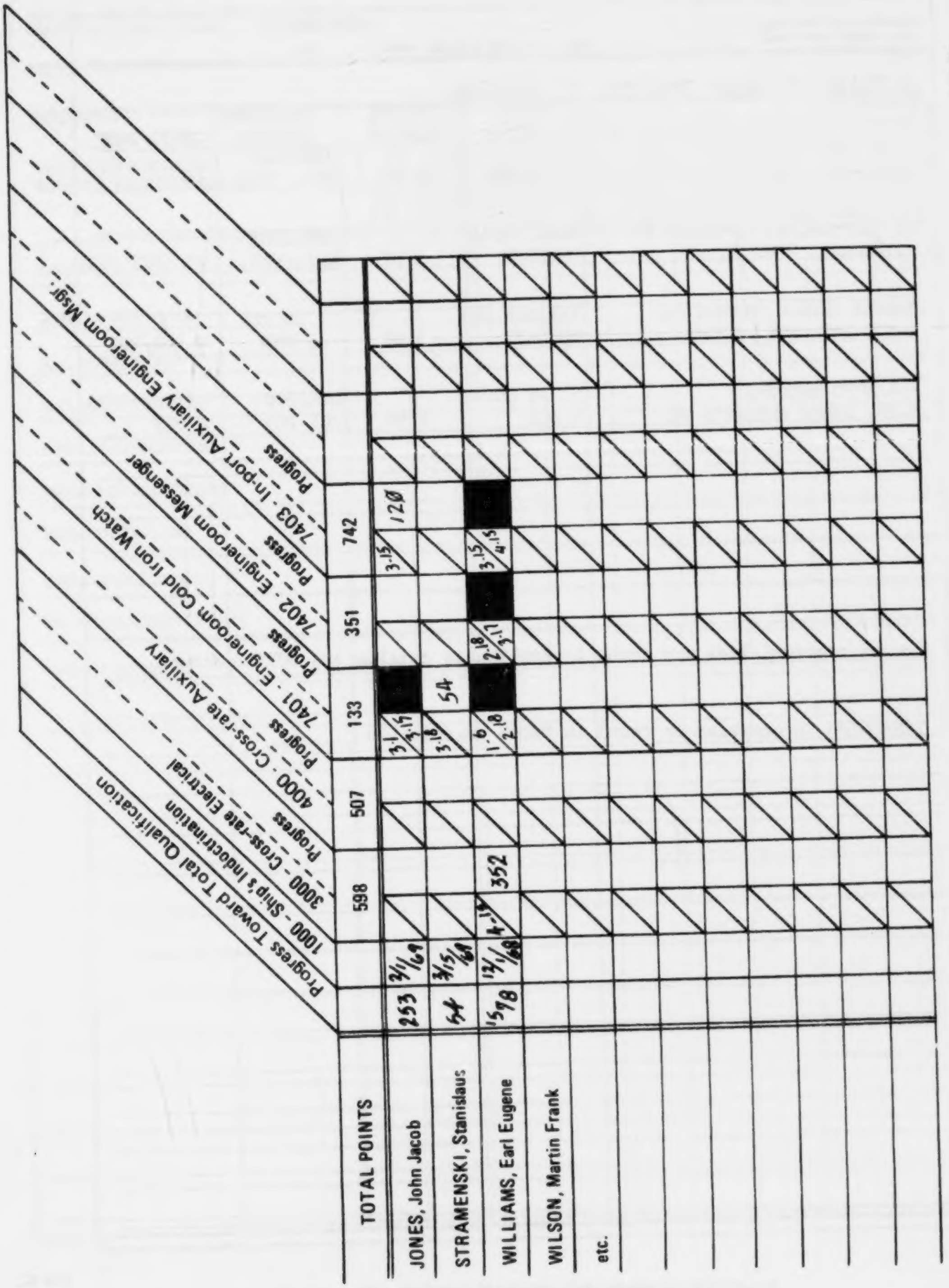
TITLE
Record of Qualifications at Battle Stations for Crew of Mount 31, 3"/50

COLUMN CAPTIONS

Page 1 of 1 page									
Date assigned to Mt 31									
Date transferred from Mt 31									
Date his previous 3"/50 qual entered this record									
HAS STUDIED AND KNOWS THE BELOW LISTED ITEMS:									
Hangfire-misfire procedure			Date						
Identification markings of 3" ammo. (OP4)			Initials						
Safety precautions									
Ammo service to guns									
All duties of 3"/50 gun crew given in Ship's Gunnery Doctrine									
Ship's Spotting Doctrine - (Mandatory only for Mt Capt)			Date & Initials						
KNOWS HOW TO REPAIR FOLLOWING COMMON CASUALTIES:									
(a) Broken firing pin									
(b) Broken firing lead									
HAS QUALIFIED TO PERFORM THE FOLLOWING DUTIES:									
(1) Mount Captain (GM only)			Note: Since this record covers a gun crew, the only applicable practical factor is the qualification as a Mount Captain for gunner's mates.						
(2) Pointer									
(3) Trainer									
(4) Sightsetter									
(5) 1st loader									
(6) Fuzesetter									
(7) Passer									
(8) Hot shellman									

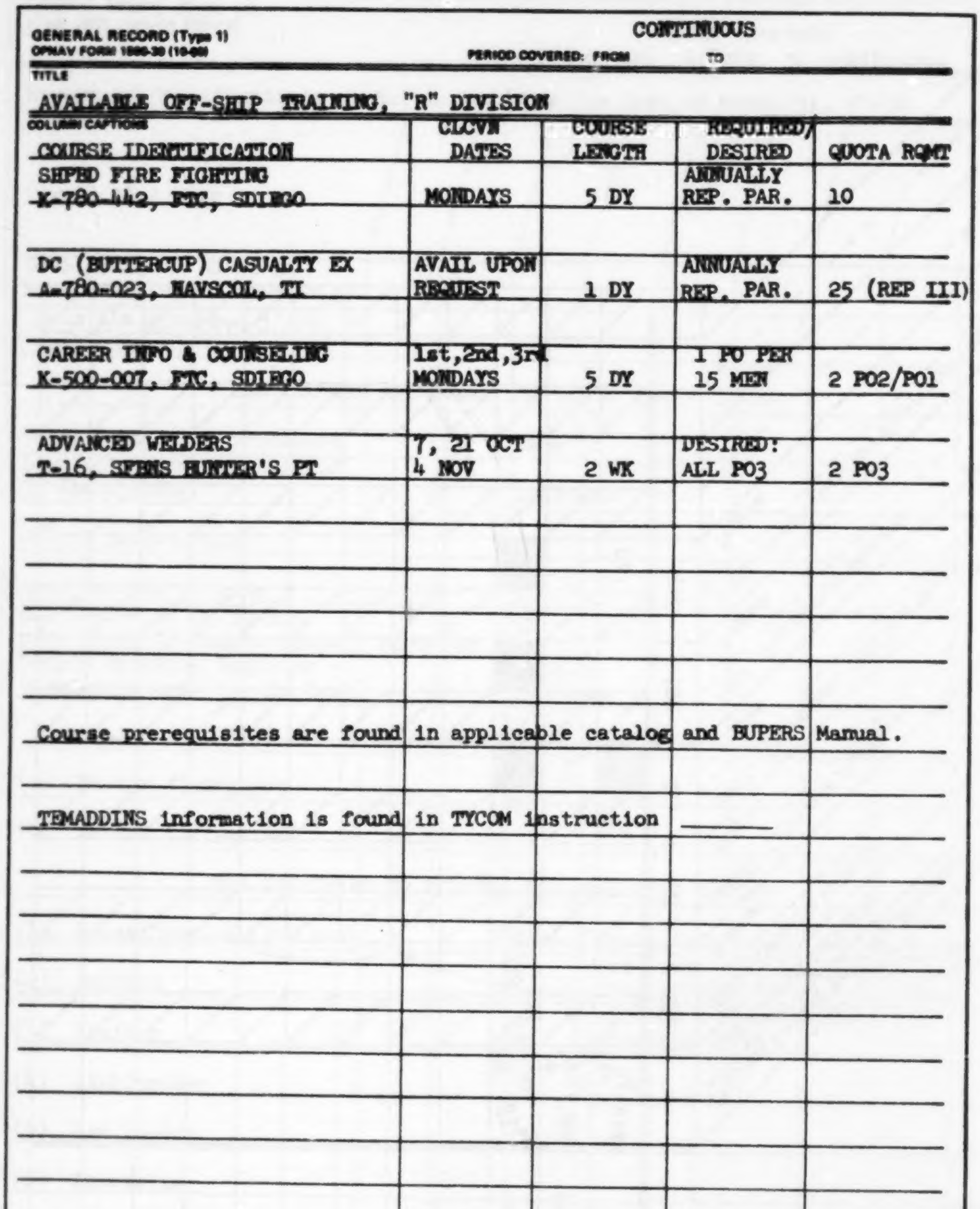
114.80

Figure 1-16.—Record of Qualifications at Watch/Battle Stations.


Progress Toward Total Qualification
1000 - Ship's Indoctrination
3000 - Cross-rate Electrical
Progress
4000 - Cross-rate Auxiliary
Progress
7401 - Engineroom Cold Iron Watch
Progress
7402 - Engineroom Messenger
Progress
7403 - In-port Auxiliary Engineroom Msgr.
Progress
TOTAL POINTS
598
507
133
351
742
JONES, John Jacob
253
2/1/69
3-1
3-15
3-15
120
STRAMENSKI, Stanislaus
64
3/15/69
3-18
54
WILLIAMS, Earl Eugene
1598
12/1/68
4-15
352
1-6
2-18
2-18
3-17
3-15
4-15
WILSON, Martin Frank
etc.

114.81

Figure 1-17.—Record of Progress Chart.



GENERAL RECORD (Type 1)
OPNAV FORM [illegible]-30 (10-[illegible])

CONTINUOUS

PERIOD COVERED: FROM TO

TITLE

AVAILABLE OFF-SHIP TRAINING, "R" DIVISION

COLUMN CAPTIONS

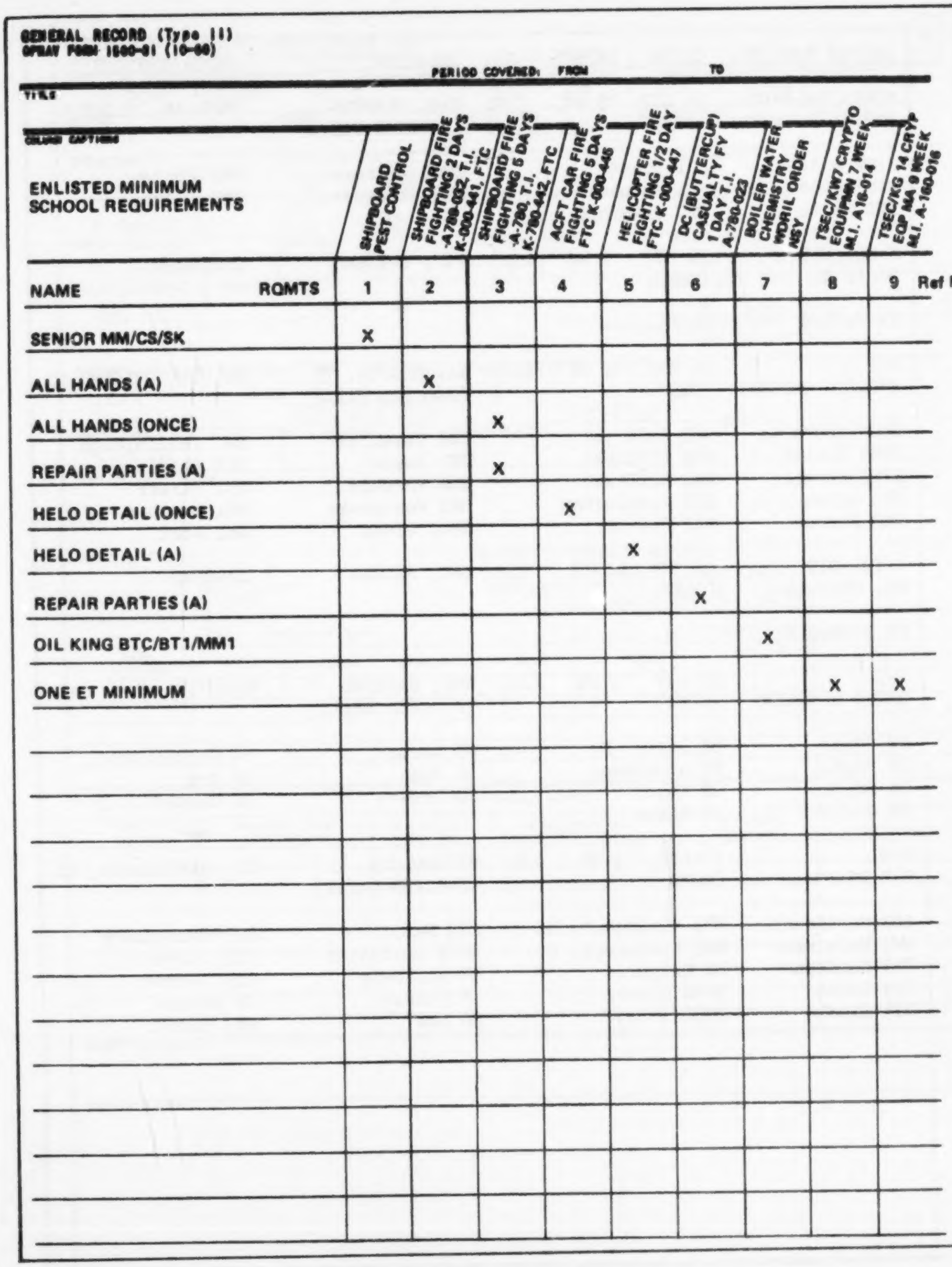
COURSE IDENTIFICATION	CLCVN DATES	COURSE LENGTH	REQUIRED/ DESIRED	QUOTA RQMT
SHPBD FIRE FIGHTING K-780-442, FTC, SDIEGO	MONDAYS	5 DY	ANNUALLY REP. PAR.	10
DC (BUTTERCUP) CASUALTY EX A-780-023, NAVSCOL, TI	AVAIL UPON REQUEST	1 DY	ANNUALLY REP. PAR.	25 (REP III)
CAREER INFO & COUNSELING K-500-007, FTC, SDIEGO	1st,2nd,3rd MONDAYS	5 DY	1 PO PER 15 MEN	2 PO2/PO1
ADVANCED WELDERS T-16, SFBNS HUNTER'S PT	7, 21 OCT 4 NOV	2 WK	DESIRED: ALL PO3	2 PO3

Course prerequisites are found in applicable catalog and BUPERS Manual.

TEMADDINS information is found in TYCOM instruction ______

114.82

Figure 1-18.—Available Off-Ship Training, "R" Division.



GENERAL RECORD (Type II)
OPNAV FORM 1500-31 (10-60)

PERIOD COVERED: FROM TO

TITLE

COLUMN CAPTIONS

ENLISTED MINIMUM SCHOOL REQUIREMENTS

		SHIPBOARD PEST CONTROL	SHIPBOARD FIRE FIGHTING 2 DAYS -A789-032, T.I. K-000-441, FTC	SHIPBOARD FIRE FIGHTING 5 DAYS -A-780, T.I. K-780-442, FTC	ACFT CAR FIRE FIGHTING 5 DAYS FTC K-000-445	HELICOPTER FIRE FIGHTING 1/2 DAY FTC K-000-447	DC (BUTTERCUP) CASUALTY FY 1 DAY T.I. A-780-023	BOILER WATER CHEMISTRY WDRIL ORDER NSY	TSEC/KW7 CRYPTO EQUIPMN 7 WEEK M.I. A16-014	TSEC/KG 14 CRYP EQP MA 9 WEEK M.I. A-160-016	
NAME	RQMTS	1	2	3	4	5	6	7	8	9	Ref Nrs
SENIOR MM/CS/SK		X									
ALL HANDS (A)			X								
ALL HANDS (ONCE)				X							
REPAIR PARTIES (A)				X							
HELO DETAIL (ONCE)					X						
HELO DETAIL (A)						X					
REPAIR PARTIES (A)							X				
OIL KING BTC/BT1/MM1								X			
ONE ET MINIMUM									X	X	

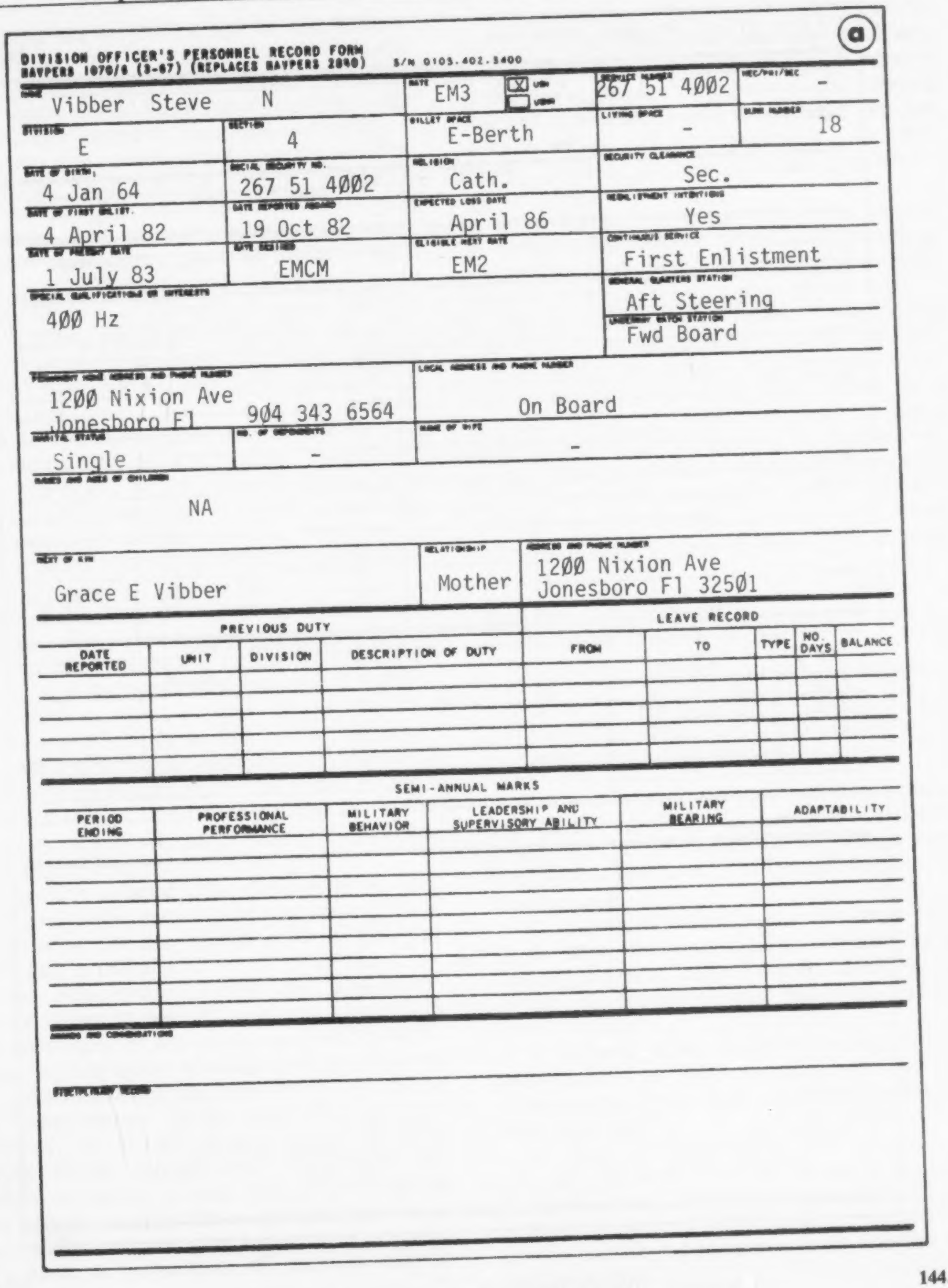
114.83

Figure 1-19.—Enlisted Minimum School Requirements.

COURSE NAME/NO.	CLCVN	LENGTH	NO.	LOCATION	QUOTA CONTROL
COMFAIRALAMEDA	16 SEP	5 DY	(10)	NAS, ALAMEDA	COMFAIR, ALAMEDA
CAREER COUNSEL	(CQNR:		)	(PROCEED DAILY)	
SPCM Wilson	CS1 Pratt			GMG1 Belmore	MM2 Worley
SKCM Smith	BT1 Spaniol			BT2 Strasser	EM1 Padua
BTC Smith	EMC Crawford				
K-201-840	16 SEP	6 WK	(2)	FTC, SDIEGO	COMTRAPAC
BASIC SM	(CQNR:		)		
SN Hinton	SA Peltola				
W-5	16 SEP	5 DY	(20)	NAVCOLSCOM, TI	CO, NAVSCOLCOM. TI
NUCLEAR DEFENSE	(CQNR:		)	(PROCEED DAILY)	
BMCM Schwartz	BM3 Anderson			CS1 Cavalier	BMC Peckinpaugh
SFM3 Bolick	BM2 O'Conner			SM1 Boyer	DK2 Ahlfinger
SFM3 Stoehr	MM1 Collison			SDL Mercado	QM1 Parker
SF1 Allen	BT2 Washington			BM2 Kolcynski	MM1 Louthan
SK2 Ferrer	MM2 Pierce			GMQC Grant	MM1 Mort
A-702-019	16 SEP	12 WK	(1)	SSC, SDIEGO	EPDOPAC
MR, CLASS A	(CQNR:		)		
FN Bridwell					
T-9	23 SEP	5 DY	(14)	NSC, OAKLAND	NAVSCOLS, NSC, OAK
CARGO HANDLING	(CQNR:		)	(PROCEED DAILY)	
SN Owens	SN Smith, D.			SN Lerma	SN Chateauneuf
SN Rauch	SN Atchinson			SN Pena	SN Cox
SN Snyder	SN Keith			SN Pruess	SN Campbell, J.
SN Cuzick	SN Eaton				
S-9	23 SEP	5 DY	(20)	NAVSCOLCOM, TI	CO, NAVSCOLCOM, TI
DIV DC PO's	(CQNR:		)	(PROCEED DAILY)	
EN3 Martinson	MM3 Dominguez, M.			CS3 Nappi	BM3 Montgomery
MM3 Martinez	MM3 Dominguez, P.			BMSN Balthazor	SK3 Carver
EM3 Kauffman	FN Kilgore			SN Holloway	SK3 Sterner
BT3 Leach	BMSN Slater			SN Conner	SN Romero
BT3 Eisele	GMG3 Yates			SN Lee	PN3 Hinkel

114.84A

Figure 1-20.—Format for Scheduling and Planning Off-Ship School Training.



(a)

DIVISION OFFICER'S PERSONNEL RECORD FORM
NAVPERS 1070/6 (3-67) (REPLACES NAVPERS 2840) S/N 0105.402.3400

NAME: Vibber Steve N
RATE: EM3
☒ USN
☐ USNR
SERVICE NUMBER: 267 51 4002
NEC/PRI/SEC: -
DIVISION: E
SECTION: 4
BILLET SPACE: E-Berth
LIVING SPACE: -
BUNK NUMBER: 18
DATE OF BIRTH: 4 Jan 64
SOCIAL SECURITY NO.: 267 51 4002
RELIGION: Cath.
SECURITY CLEARANCE: Sec.
DATE OF FIRST ENLIST.: 4 April 82
DATE REPORTED ABOARD: 19 Oct 82
EXPECTED LOSS DATE: April 86
REENLISTMENT INTENTIONS: Yes
DATE OF PRESENT RATE: 1 July 83
RATE DESIRED: EMCM
ELIGIBLE NEXT RATE: EM2
CONTINUOUS SERVICE: First Enlistment
SPECIAL QUALIFICATIONS OR INTERESTS: 400 Hz
GENERAL QUARTERS STATION: Aft Steering
UNDERWAY WATCH STATION: Fwd Board
PERMANENT HOME ADDRESS AND PHONE NUMBER: 1200 Nixion Ave, Jonesboro Fl 904 343 6564
LOCAL ADDRESS AND PHONE NUMBER: On Board
MARITAL STATUS: Single
NO. OF DEPENDENTS: -
NAME OF WIFE: -
NAMES AND AGES OF CHILDREN: NA
NEXT OF KIN: Grace E Vibber
RELATIONSHIP: Mother
ADDRESS AND PHONE NUMBER: 1200 Nixion Ave, Jonesboro Fl 32501

PREVIOUS DUTY				LEAVE RECORD				
DATE REPORTED	UNIT	DIVISION	DESCRIPTION OF DUTY	FROM	TO	TYPE	NO. DAYS	BALANCE

SEMI-ANNUAL MARKS

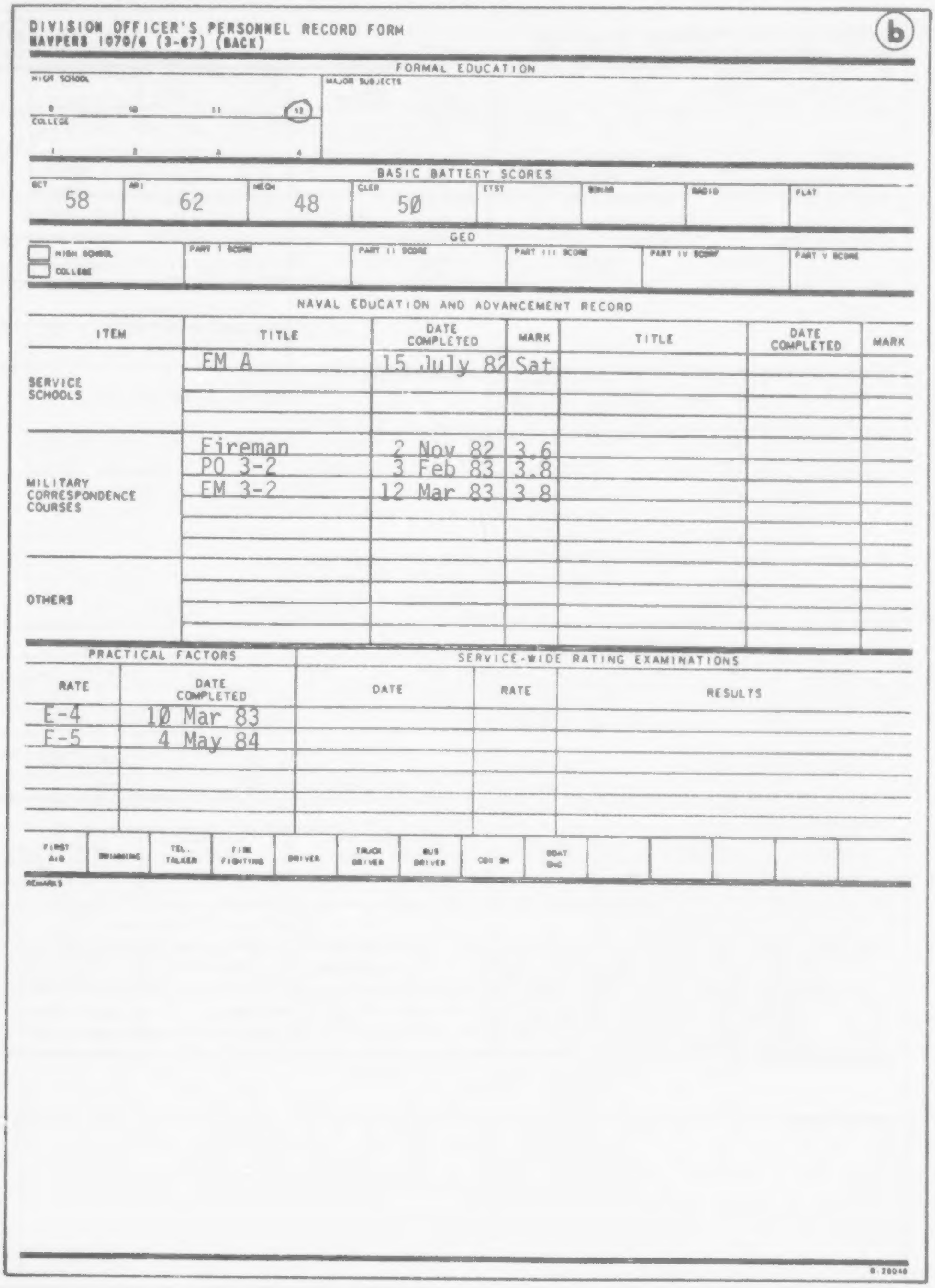
PERIOD ENDING	PROFESSIONAL PERFORMANCE	MILITARY BEHAVIOR	LEADERSHIP AND SUPERVISORY ABILITY	MILITARY BEARING	ADAPTABILITY

AWARDS AND COMMENDATIONS:

DISCIPLINARY RECORD:

144.84B

Figure 1-21.—Division Officer's Personnel Record Form.



DIVISION OFFICER'S PERSONNEL RECORD FORM
NAVPERS 1070/6 (3-67) (BACK)

(b)

FORMAL EDUCATION

HIGH SCHOOL 9 10 11 [✓ 12]	MAJOR SUBJECTS
COLLEGE 1 2 3 4	

BASIC BATTERY SCORES

GCT	ARI	MECH	CLER	ETST	SONAR	RADIO	FLAT
58	62	48	50				

GED

☐ HIGH SCHOOL ☐ COLLEGE	PART I SCORE	PART II SCORE	PART III SCORE	PART IV SCORE	PART V SCORE

NAVAL EDUCATION AND ADVANCEMENT RECORD

ITEM	TITLE	DATE COMPLETED	MARK	TITLE	DATE COMPLETED	MARK
SERVICE SCHOOLS	EM A	15 July 82	Sat			
MILITARY CORRESPONDENCE COURSES	Fireman	2 Nov 82	3.6			
	PO 3-2	3 Feb 83	3.8			
	EM 3-2	12 Mar 83	3.8			
OTHERS						

PRACTICAL FACTORS		SERVICE-WIDE RATING EXAMINATIONS		
RATE	DATE COMPLETED	DATE	RATE	RESULTS
E-4	10 Mar 83			
E-5	4 May 84			

FIRST AID	SWIMMING	TEL. TALKER	FIRE FIGHTING	DRIVER	TRUCK DRIVER	BUS DRIVER	CBR SH	BOAT ENG					

REMARKS

B-78040

144.84B

Figure 1-22.—Division Officer's Personnel Record Form—Continued.

If there are several ratings or groups in a division and they ordinarily do not conduct drills or instruction periods together, separate record sheets should be prepared for each rating or group (for example, SM, RM, and QM).

Certain drills are repeated over and over on a frequent basis for the benefit of watch standers. The signal watch standers should send and receive drill messages during each watch whenever opportunity permits. Drills of this nature need NOT be formally scheduled.

The Record of Qualification at Watch/Battle Stations shows the knowledge and skills required of personnel who man battle stations such as repair parties, gun crews, and combat information center (CIC) teams, as well as condition watches. This record should not duplicate the PQS Progress Chart. (Figure 1-16 shows the form of the record.) Provision is made for recording items of desired knowledge, qualification of various duties at battle/watch stations, and proficiency in carrying out important machinery casualty procedures.

The PQS Progress Chart displays which persons are in training for each watch. It also indicates each person's progress toward qualification and the watches on which each person is qualified.

The top of the form lists all the qualifications and watch stations, including code numbers, and a progress column with total points for each for which the division is responsible. Down the left side, names of the persons assigned are listed (fig. 1-17).

The first column after the names is used to record point credit progress toward final qualification in the specialty for which the individual is training.

The indoctrination, cross rate, and watch station columns intersect with the name lines and are divided by a diagonal into two triangles. When an individual is assigned to proceed on any given qualification, the date is entered in the upper triangle. In the companion progress columns, the trainee records weekly the total points earned toward each assignment. By comparing points earned with points required and lapsed time since the assignment was made, each individual and the respective supervisor will have an indication of progress toward qualification.

When a trainee has been qualified by the head of the department or commanding officer, as appropriate, the completion date is entered in the lower triangle. The adjacent square is then blacked out. Also, as each individual completes a PQS watch station qualification, an entry should be made on page 4 of the individual's service record.

Formal school training records can be used to assemble information on all Navy schools of interest to the division and to plan for progressive use of schools during the training cycle.

Figure 1-18 shows the format for a division record of available off-ship training. An additional record of school requirements which could be helpful to a division officer or a training officer of a unit is shown in figure 1-19. Scheduling and planning for schools can be organized in a format similar to figure 1-20. This serves as a plan and a record. Division officers should arrange for schooling, where possible, to qualify on-board reliefs for personnel due for detachment.

Personnel Advancement Requirements (PARs)

The Group Record of Practical Factors is a record of divisional training in PARs. (Figure 3-3 shows the form of the record.) It can be prepared and used as follows:

1. The printed entries in the left-hand column can be cut from the appropriate NAVPERS PARs sheet and attached to the record card. Each side of each card will handle entries for nine persons.
2. Individual training can be noted by a check mark, and qualification recorded by an inked *Q* and date. Large divisions having several ratings or groups should maintain separate group records.
3. A glance at this record at the beginning of each quarter can guide you in scheduling individual instruction in practical factors during the next three months.
4. Once this record has been prepared, it may be used until most of the personnel have been transferred. When the card is filed, entries applying to persons still attached to the division can be transferred to a new form and the old card destroyed.

5. For qualifications to be authentic, the immediate petty officer supervisors should certify them since they have the best knowledge of the abilities of their subordinates. Your qualifications should be certified by the division officer.

6. When a person is transferred, the qualifications shown on the record should be transferred to an individual record of PARs and be kept in the individual's service record. The group record includes a satisfactory substitute for the requirement that the supervising officer holds a copy of NAVPERS 1414/4 for each person in pay grades E-3 through E-8.

7. Completion of PARs by an individual for a particular rate must be recorded in the individual's service record.

Personnel Qualification Standards (PQS)

The PQS Program (OPNAVINST 3500.34B) is a method of qualifying officer and enlisted personnel to perform assigned duty. PQS is a written compilation of knowledge and skills required to qualify for a specific watch station, maintain a specific equipment or system, or perform as a team member within the assigned unit. PQS is in the format of a qualification guide, which asks the questions a trainee must answer to verify readiness to perform a given task. It also provides a record of the progress and final certification. The PQS approach to training is based on individual learning. The learner has the complete written program in hand. The operational supervisor serves as both a source for specific assistance and as quality control over the learning process through certification of completion of each step. NAVEDTRA 43100-1 (*Handbook on Personnel Qualification Standards*) provides information on the PQS concept and describes its implementation into the training program of operational units of the Navy.

REFERENCES

Engineering Administration, NAVEDTRA 10858-F

Storekeeper 3 & 2, NAVEDTRA 10269-J

Military Requirements for PO 1 & C, NAVEDTRA 10057-D

Military Requirements for PO 3 & 2, NAVEDTRA 10057-E1

NAVSEA S9086-KC-STM-000, chapter 300

CHAPTER 2

INSPECTIONS AND MAINTENANCE

Naval ships and shore installations are required to be inspected to ensure that their operation, administration, and equipment reflect a high standard of readiness. The frequency with which the various types of inspections are held is determined by the CNO, fleet commanders, and type commanders. As far as any specific ship is concerned, the cognizant type commander usually designates the type of inspection and when it will be held.

Your command will usually be notified in advance as to when various inspections will take place, but preparations for such inspections should not be postponed until the notices are received. It is a mistake to think that a poorly administered division or department can, by a sudden burst of energy, be prepared to meet the inspector's eagle eye. By using proper procedures and keeping up to date on such items as repair work, maintenance work, operating procedures, training of personnel, engineering casualty control drills, maintenance records, and reports, you will always be ready for any type of inspection at any time.

Since your ship may be designated to provide personnel to perform an inspection on another command, you, as a PO1 or CPO, may be assigned the duty as an assistant inspector. Therefore, you should know something about the different types of inspections and trials and how they are conducted.

ADMINISTRATIVE INSPECTIONS

Administrative inspections cover administrative methods and procedures normally used by the ship. Each inspection is divided into two general categories—the general administration of the ship as a whole and the administration of each department. In this discussion, we will consider the engineering department only.

The purpose of an administrative inspection is to determine whether or not the department is being administered within the guidelines established by the standard organization and regulations manual of the United States Navy, *Engineering Department Organization Manual*, and other pertinent instructions.

INSPECTING PARTY

It is a routine procedure for one ship to conduct an inspection of a similar division on another ship. General instructions for conducting the inspection are usually given by the division commander; however, the selecting and organizing of the inspecting party are done aboard the ship that must conduct the inspection.

The chief inspector, usually the commanding officer of the ship, will organize the assisting board. The organization of the assisting board, in general conformance with the departmental organization of the ship, is divided into appropriate groups, each headed by an inspector with as many assistant inspectors as necessary. Chief petty officers and petty officers first class may be assigned as assistant inspectors.

The engineering department inspecting group (or party) is organized and supervised by the engineer officer. The manner in which an individual inspection is carried out depends to a great extent upon the knowledge and ability of the members of the group (or party).

GENERAL INSPECTION OF THE SHIP AS A WHOLE

One of the two categories of administrative inspection is the general administration of the ship as a whole. Items of this inspection that will have a direct bearing on the engineering department, and for which the report of inspection indicates a grade, are as follows:

1. Appearance, bearing, and smartness of personnel
2. Cleanliness, sanitation, smartness, and appearance of the ship as a whole
3. Adequacy and condition of clothing and equipment of personnel
4. General knowledge of personnel in regard to the ship's organization, ship's orders, and administrative procedures
5. Dissemination of all necessary information among the personnel
6. Indoctrination of newly reported personnel
7. General education facilities for individuals
8. Comfort and conveniences of living spaces, including adequacy of light, heat, ventilation, and fresh water
9. Economy of resources

ENGINEERING DEPARTMENT INSPECTION

The engineering department administrative inspection is primarily the inspection of the engineering department paper work, which includes publications, bills, files, books, records, and logs. Additionally, this inspection includes other items with which the chief petty officers and petty officers first class must be concerned. Some of these items are the cleanliness and preservation of machinery and engineering spaces; the training of personnel; the assignment of personnel to watches and duties; the proper posting of operating instructions and safety precautions; the adequacy of warning signs and guards; the marking and labeling of lines and valves; and the proper maintenance of operating logs.

ADMINISTRATIVE INSPECTION CHECKOFF LISTS

Administrative inspection checkoff lists are usually furnished to the ship by the type commander. These lists are used as an aid for inspecting officers and inspecting party personnel to assist them in ensuring that no important item is overlooked. The inspecting personnel, however, should not accept these lists as being all-inclusive, since usually during an inspection, additional items develop that must be considered or observed.

As a petty officer, you should be familiar with the various checkoff lists used for inspections. These checkoff lists will give you a good understanding of how to prepare for an inspection as well as how to carry out your daily supervisory duties. You will find it helpful to obtain copies of the various inspection checkoff lists from the log room and to carefully look them over. They will give detailed information about what type of inspection you may expect for your type of ship.

The following is an abbreviated sample of an engineering department checkoff list. You should get a better understanding of the scope and purpose of administrative inspections by reviewing this list.

1. BILLS FOR BOTH PEACE AND WAR

a. Inspect the following, among others, for completeness, correctness, and adequacy.

(1) Department Organization
(2) Watch, Quarter, and Station Bills
(3) Engineering Casualty Bill
(4) Fueling Bill

2. ADMINISTRATION AND EFFECTIVENESS OF TRAINING

a. Administration and effectiveness of training of personnel for current and prospective duties.

(1) Are sufficient nonrated personnel in training to replace anticipated losses?
(2) NAVEDTRA training courses.

(a) Number of personnel enrolled
(b) Percentage of personnel in department enrolled
(c) Number of personnel whose courses are completed

(3) Are personnel concerned familiar with operating instructions and safety precautions? (Question personnel at random.)

(4) Are personnel concerned properly instructed and trained to handle casualties to machinery?

(5) Are personnel properly instructed and trained in damage control?

(6) Are training films available and used to the maximum extent?

(7) Are training records of personnel adequate and properly maintained?

3. DISSEMINATION OF INFORMATION WITHIN DEPARTMENT

a. Is necessary information disseminated within the department and divisions?

b. Are the means of familiarizing new personnel with department routine orders and regulations considered satisfactory?

4. ASSIGNMENT OF PERSONNEL TO STATIONS AND WATCHES

a. Are personnel properly assigned to battle stations and watches?

b. Are sufficient personnel aboard at all times to get the ship under way?

c. Are personnel examined and qualified for important watches?

d. Does it appear that personnel on watch have been properly instructed? (Question personnel at random.)

5. THE OPERATING INSTRUCTIONS, SAFETY PRECAUTIONS, PMS, AND CHECKOFF LISTS

a. Inspect completeness of the following:

(1) Operating instructions posted near machinery

(2) Posting of necessary safety precautions

b. Are PMS schedules properly posted and maintained in the working spaces?

c. Is the Master PMS Schedule posted and up to date?

d. Are responsible personnel familiar with current instructions regarding routine testing and inspections?

e. Are starting-up and securing sheets properly used?

6. PROCEDURES FOR PROCUREMENT, ACCOUNTING, INVENTORY, AND ECONOMY IN USE OF CONSUMABLE SUPPLIES, REPAIR PARTS, AND EQUIPAGE

a. Is an adequate procedure in use for replacement of repair parts?

b. Are there adequate measures used to prevent excessive waste of consumable supplies?

c. Is there proper supervision in the proper supply of, care of, and accountability for hand tools?

d. Are inventories taken of repair parts which are in the custody of the engineering department?

e. How well are repair parts preserved and stowed?

f. What type of system is used to locate a repair part carried on board? (Have a chief or first class petty officer explain to you how a repair part for a certain piece of machinery is obtained.)

g. Are custody cards properly maintained for accountable tools and equipment?

7. MAINTENANCE OF RECORDS AND LOGS

a. Inspect the following for compliance with pertinent directives, completeness, and proper form.

(1) Engineering Log
(2) Bell Book
(3) Operating Records
(4) Maintenance Records
(5) Alteration and Installation Program
(6) Daily Oil and Water Records
(7) Engineering Reports
(8) Training Logs and Records
(9) Work Books for Engineering Spaces

8. AVAILABILITY AND CORRECTNESS OF PUBLICATIONS, DIRECTIVES, AND TECHNICAL REFERENCE MATERIAL

a. Engineering Blueprints Recommended

(1) Ship's Plan Index (SPI)
(2) Proper indexing of blueprints
(3) Completeness and condition

b. Manufacturers' Instruction Books

(1) Proper indexing
(2) Completeness and condition

c. Type Commanders Material Letters
d. NAVSEA Technical Manual
e. General Information Book
f. Booklet Plans of Machinery

9. CLEANLINESS AND PRESERVATION

a. Preservation and cleanliness of space (including bilges)
b. Preservation and cleanliness of machinery and equipment
c. Neatness of stowage
d. Condition of ventilation
e. Condition of lighting
f. Compliance with standard painting instructions

OPERATIONAL READINESS INSPECTION

The operational readiness inspection is conducted to ensure that the ship is ready and able to perform the operations which might be required of it in time of war.

This inspection consists of the conduct of a battle problem and of other operational exercises. A great deal of emphasis is placed on antiaircraft and surface gunnery, damage control, engineering casualty control, and other appropriate exercises. Various drills are held and observed, and the ship is operated at full power for a brief period of time.

The overall criteria of performance include the following:

1. Can the ship as a whole carry out its operational functions?

2. Is the ship's company well trained, well instructed, competent, and skillful in all phases of the evolutions?

3. Is the ship's company stationed following the ship's Battle Bill, and does the Battle Bill meet wartime requirements?

OBSERVING PARTY

The personnel and organization of the operational readiness observing party are similar to those of the administrative inspection party. However, more personnel are usually required for the operational readiness observing party. These additional personnel are often chief petty officers and first class petty officers.

The observing party members are briefed in advance of the scheduled exercises and drills that are to be conducted. They must have sufficient training and experience so that they can properly evaluate the exercises and drills that are to be held. Each observer is usually assigned to a specific station and should be well qualified in the procedure of conducting drills and exercises for that station. That each observer be familiar with the type of ship to be inspected is also highly desirable.

BATTLE PROBLEMS

In this discussion, we will consider the battle problem from the viewpoint of the observer and present some general information on the requirements and duties of a member of the engineering department observing party. The knowledge of the viewpoint and duties of an observer should help you prepare yourself and your personnel for a battle problem and other appropriate exercises.

PREPARATION OF A BATTLE PROBLEM

The degree of perfection achieved in any battle problem is reflected in the skills and applications of those who prepare it. A great deal depends upon the experience of officers and chief petty officers.

The primary purpose of a shipboard battle problem is to provide a medium for testing and evaluating the ability of all divisions of the engineering department to function together as a team in simulated combat operations.

Battle problems are the most profitable and significant of all peacetime training experience, since they demonstrate a department's readiness for combat. The degree of realism of this test determines their value: the more nearly it approximates actual battle conditions, the more valuable it is.

Another element in the conduct of a battle problem which significantly increases the value of these tests to the ship's company is the element of surprise.

CONDUCT OF A BATTLE PROBLEM

Before a battle problem is to be conducted, the ship is furnished specific information such as that listed below.

1. Authority for conducting the inspection
2. Time of boarding of the inspecting party
3. Time the ship is to get under way
4. Time for setting the first material readiness condition
5. Time for conducting the inspection to zero problem time conditions
6. Zero problem time
7. End of problem time
8. Time of critique

Observers must be proficient in the proper methods of introduction of information. In general, when practical, the information delivered to ship's personnel should be verbal and should contain only that information which would help the ship's personnel develop adequate procedures for the search and investigation of the imposed casualty. In the event the ship's personnel fail to locate the casualty, the observer may resort to coaching, but a notation should be made on the observer's form as to the time allowed before coaching and information were furnished. Special precautions should be taken to give the symptoms of casualty the same degree of realism that they would have if the casualty were actual rather than simulated.

To impose casualties, ship's personnel must close valves, open switches, or stop machinery. In each case, the observer should inform responsible ship's personnel of the action desired, and the ship's personnel should operate the designated equipment. A casualty should be simulated, or omitted entirely, if there is danger that personnel injury or material damage might result. The supply of lubricating oil to the main engines or the supply of feedwater to the boilers MUST NOT be stopped to simulate casualties.

An emergency procedure should be set up by the observing party and ship's company to ensure proper action in case actual casualties—as distinguished from simulated or problem casualties—should occur.

Although the general announcing system (the 1MC circuit) may be used by the ship's company, observers, normally, have priority in its use. The problem-time announcer uses the general announcing system to announce the start of the battle problem, the problem time at regular intervals, the conclusion of the problem, and the restoration of casualties. The general announcing system is kept available at all times for use in case of actual emergency. All other announcing system circuits and other means of interior communications are reserved for the use of the ship.

Engineering telephone circuits should be monitored by one or more observers. A check should be made for proper procedure, for circuit discipline, and for proper handling of information or casualties.

An inspection should be made to see that the engineering plant is properly split following current directives. Fire hazards, such as paint, rags, or oil, and missile hazards, such as loose gear, loose floor plates, toolboxes, and repair parts boxes should be noted. The condition of fire fighting, damage control, and remote control gear should be carefully inspected.

ANALYSIS OF THE BATTLE PROBLEM

The maximum benefit obtained from conducting a battle problem lies in pinpointing existing weaknesses and deficiencies and in resulting recommendations for improvement in organization and training. Every effort should be made by the observers to emphasize strong points as well as deficiencies. Knowledge of existing strong points is helpful to boost the morale of the ship's personnel.

Analysis of the battle problem affords the observers an opportunity to present to the ship's company their opinion of its performance and for the ship's company to comment on the observers' remarks as well as to consider suggested improvements.

Analysis is conducted in two steps: the critique and the observers' report.

A critique of the battle problem is held on board the observed ship before the observing party leaves, so the problems and the actions taken may be reviewed when they are fresh in the minds of all concerned. The critique is attended by all the ship's officers, appropriate chief and first class petty officers, the chief observer, and all senior observers. The various points of interest of the battle problem are discussed, and the chief observer comments on the overall conduct of the problem after the senior observers complete their analysis of the battle problem as reported in their observers' reports.

The observers' reports are prepared in the form prescribed by the type commander and include any additional instructions given by the chief observer. The reports of the observers are collected by the senior observer for each department and are submitted to the chief observer. All observers' reports are reviewed by the senior observers before the critique is held.

The observers' reports provide the inspected ship with detailed observations of the battle problem which, because of time limitations, may not have been brought out during the critique. The inspected ship receives a copy of all observers' reports; in this way, each department is given the opportunity to review the comments and set up a training schedule to cover the weak points.

The following is an example of an engineering observer's report.

Engineering observer ____________

Location ____________

1. The engineering department's evaluation is based on the following:

a. Extent of the department's preparation and fulfillment of the ordered conditions of readiness as appropriate to the problems.

b. Extent of correct utilization of the engineering damage control features built into the ship.

c. Extent to which proper engineering casualty control is accomplished.

d. Extent to which on station personnel take corrective action for control of damage.

e. Adequacy of reports and dissemination of information.

f. The general handling of the plant following good engineering practice and the ability of the department to ensure maximum mobility and maneuverability of the ship and to supply all necessary services to other departments in fighting the ship.

2. Hit ____________

Exercise ____________

a. Preparation and status of the plant.

b. Fulfillment of proper conditions of readiness.

c. Fire and missile hazards.

d. Condition of fire fighting and damage control gear.

e. Condition of personnel clothing and protection.

f. Stationing and readiness of personnel.

g. Investigation and interpretation of casualty.

h. Promptness and effectiveness in taking care of casualty.

i. Were proper doctrine and procedures used?

j. Were prompting and additional information given by observer?

k. Were proper reports made?

l. Readiness of standby units.

m. Readiness of alternate and emergency lighting and power.

n. Were proper safety precautions observed?

o. Material deficiencies.

p. Coordination of personnel.

q. Coordination of engineering spaces.

3. Main engine control. Receipt of vital interior communications, origination and transmission of required reports to Conn, Damage Control Central, and other stations.

4. Action taken by main engine control.

   a. Correct action
   b. Sound judgment based on good practice
   c. Assurance
   d. Speed

5. Recommendations.

The blank parts of the observers' report forms are filled in as applicable to the individual observer's station. Items that were not observed are either left blank or crossed out. Additional information, if required for a certain exercise or condition, may be written on the reverse side of the form. A separate form or sheet is used for each exercise or drill. Remarks or statements made by the observer should be clear and legible.

MATERIAL INSPECTION

The purpose of material inspection is to determine the actual material condition of the ship. On the basis of what the inspection discloses, it may be necessary to recommend repairs, alterations, changes, or developments which will ensure the material readiness of the ship to carry out the mission for which it was designed. In addition, the material inspection determines whether or not proper procedures are being carried out in the care and operation of the machinery and the equipment. Administrative procedures and material records which are inspected include maintenance records and routine tests and inspections.

The requirements prescribed for material readiness are as follows:

1. Established routines for the conduct of inspections and tests, schedule for preventive maintenance, and a system which will ensure timely and effective repairs.
2. Adequate material maintenance records, kept in accordance with current directives, that give the history and detailed description of the condition of the machinery and the equipment.
3. Planned and effective utilization of the ship's facilities for preservation, maintenance, and repair.
4. Correct allocation of necessary work to the following categories:

   a. The ship's force.
   b. The tenders and repair ships.
   c. The naval shipyards or other shore repair activity.

The scope of the material inspection is similar to that of the inspection made by the Board of Inspection and Survey. (These inspections are discussed later in this chapter.) These inspections should be thorough and searching, and cover, in detail, maintenance and repair rather than general appearance. The distinction between administrative inspections and material inspections should be readily recognized, and there should be as little duplication as possible. Examination of the material maintenance records and reports should be made to determine the material condition of the machinery and the equipment. General administrative methods, general appearance, cleanliness of compartments, and cleanliness of machinery are not part of this inspection, except in cases where they have a direct bearing on material condition.

The composition of the inspecting party for the material inspection is similar to that of the administrative inspection party.

PREPARATION FOR THE MATERIAL INSPECTION

At an appropriate time before the date of the inspection, the chief inspector will furnish the ship with advance instructions. These instructions will include the following:

1. List of machinery and major equipment to be opened for inspection. The limit to which a unit of machinery or equipment should be opened is that which is necessary to reveal known or probable defects. The units selected to be opened should be representative and, in case of a multiple-shaft ship, should not disable more than one half of the propulsion units. Proper consideration must be given to the ship's operational schedule and safety.
2. List of equipment to be operated. Auxiliary machinery such as the anchor windlass, winches, and steering gear are normally placed on this list.

3. Copies of the condition sheets. These are checkoff lists which are used for the material inspection.
4. Any additional instructions considered necessary by the type commander or other higher authority.

Each department must prepare work lists showing the items of work to be accomplished and the recommended means for accomplishment (shipyard, tender or repair ship, or ship's force during an overhaul or upkeep period). The items are arranged in the recommended order of importance and are numbered. A list of the outstanding alterations is also made up for the inspection. Work lists usually consist of 5- by 8-inch cards with one repair or alteration item on each card. The work list should include all maintenance and repair items, because if material deficiencies are found during the inspection, they will be checked against the work list. If the item does not appear on the work list, a discrepancy in maintaining the required records will be noted by the inspector.

CONDITION SHEETS

Condition sheets are made up by the needs of the different material groups. The engineering department is primarily concerned with the machinery, the electrical, the damage control, and the hull condition sheets. Condition sheets contain checkoff sheets and material data sheets and consist of a large number of pages. Items for data and checkoff purposes are listed for all parts of the ship and for all machinery and equipment on board ship.

In advance of the inspection, a preliminary copy of the condition sheets of the ship to be inspected must be filled in. Detailed data for the preliminary copy is obtained from the maintenance records and reports.

An entry for any known fault or abnormal condition of the machinery or equipment is made in the proper place on the condition sheets. Details and information are given, as necessary, to indicate the material condition to the inspecting party. If corrective work is required in connection with a unit or space, a reference is made to the work list item. Data and information requested in the condition sheets should be furnished whenever possible. The preliminary copy, if properly filled out, represents the best estimate of the existing material condition of the ship.

When the condition sheets have been completed, they are turned over to the respective members of the inspecting party upon their arrival on board ship. During the inspection, the inspectors fill in the various checkoff sections of the condition sheets. These sheets are then used to prepare the final inspection report on the condition of the ship.

For more detailed information concerning a ship, you should obtain a copy of the applicable condition sheets from the engineering log room.

OPENING MACHINERY FOR INSPECTION

The ship will open machinery as previously directed by the chief inspector to obtain the inspector's opinion concerning known or probable defects. The information given in *Naval Ships' Technical Manual*, chapter 090, is used as a guide in opening particular machinery units. More detailed information on opening machinery for material inspections is found in the administrative letters of the type commander.

A list of machinery, tanks, and major equipment opened, and the extent of opening, should be supplied to the inspecting party on its arrival. Test reports on samples of lubricating oil should be furnished to the machinery inspector.

Ship's company should have portable extension lights rigged and in readiness for the units of machinery opened up for inspection. The lighting of the space should be in good order. The inspectors should be furnished flashlights, chipping hammers, file scrapers, and similar items. Precision-measuring instruments should be readily available.

ASSEMBLY OF RECORDS AND REPORTS

The material inspection also includes an inspection of various material records and reports. These documents are assembled so as to be readily available for inspection. Records must be kept up to date at all times. Check over all records to make sure that they are up to date and that nothing has been overlooked. The individual records should be filled out and maintained following current directives. Where applicable, the petty officer in charge of an engineering space should check all records or reports that concern the material or the maintenance procedures of that space.

CONDUCT OF THE INSPECTION

The inspecting group for the engineering department should conduct a critical and thorough inspection of the machinery and equipment under the responsibility of the department. The condition sheets supplied by the type commander serve as a guide and a checkoff list in making the inspection. Appropriate remarks, comments, and recommendations are entered on the condition sheets for any particular unit of machinery or equipment.

The inspectors should conduct the inspection together with the ship's personnel. No attempt must be made to follow a predetermined inspection schedule, but different units should be inspected as they are made available by the ship's company. If the ship is prepared for the inspection, there should be no delay between the inspection of the different units of machinery. It is not necessary that all machinery of one type be inspected simultaneously nor is it necessary to complete the inspection of one space before going to another.

Important items to be covered by the inspection are indicated below.

1. All opened machinery and equipment are carefully inspected, especially where the need of repair work is indicated on the work list.
2. Investigations are made to locate any defects, in addition to those already known, which may exist in material condition or design.
3. Operational tests of machinery and equipment conducted in accordance with the furnished list.
4. Electrical equipment is checked to ensure that it is not endangered by salt water from hatches, doors, or ventilation outlets. Possible leaks in piping flanges are checked.
5. Equipment in the engineering spaces is inspected to ensure that it is properly installed and maintained.
6. Supports and running gear of heavy suspended material are inspected.
7. Hold-down bolts, plates, and other members of machinery foundations are inspected. Hammers may be used for sounding, and file scrapers may be used for removing paint to disclose any condition of metal corrosion.
8. Condition sheets are checked to see that all the required information has been filled in by the ship being inspected and that all items have been checked off and filled in by the inspector.
9. Routine tests of mechanical and electrical safety devices are observed to ensure that they are being conducted according to current directives.
10. Maintenance records and reports are carefully inspected to see that they are maintained following prescribed procedures. A check is made to ensure that all known repair requirements are listed.

ANALYSIS AND REPORTS

A critique is held on board the inspected ship, at a convenient time after the completion of the material inspection, so the ship may derive the greatest benefit from the inspection. It is attended by the ship's commanding and executive officers, the heads of departments, the chief inspector, and inspectors of each inspection group, and such other personnel as may be designated from the inspected ship.

The inspectors, after receiving data from the assistant inspectors, submit reports of their inspections to the chief inspector. These reports provide the inspected ship with those observations that may not be fully discussed during the critique but are of interest to the ship's officers concerned. The inspector's reports include evaluations and any recommendations for the items inspected or observed. These reports are used by the ship as checkoff lists for corrective action and material improvement.

The chief inspector, after receiving the reports from the inspectors, makes up a report on evaluating and grading the inspection. The chief inspector discusses, with appropriate comment, the following items:

1. Those conditions requiring remedial action which should be brought to the attention of

the commanding officer of the ship inspected and to higher authority

2. Those conditions of such excellence that their dissemination will be of value to other ships

3. Those suggestions or recommendations which merit consideration by higher authority

The final smooth report is written up in a detailed procedure following the type commander's directives.

BOARD OF INSPECTION AND SURVEY INSPECTION

The Board of Inspection and Survey is under the administration of CNO. This board consists of a flag officer, as president, and of such other senior officers as may be required to assist the president in carrying out the duties of the board. Regional boards and sub-boards are established, as necessary, to assist the Board of Inspection and Survey in the performance of its duties. In this discussion, we will consider shipboard inspections that are made by the sub-boards. These sub-boards consist of the chief inspector and 10 or more members, depending upon the type of ship that is to be inspected.

MATERIAL INSPECTIONS MADE BY THE BOARD

The inspection made by the Board of Inspection and Survey is, in several respects, similar to the material inspection that has just been discussed. In fact, the Board of Inspection and Survey's inspection procedures, condition sheets, and reports are used as guidelines in establishing directives for the material inspection. The primary difference, in regard to material inspections, is that the material inspection is conducted by Forces Afloat, usually a sister ship, and the Board of Inspection and Survey inspection is conducted by a specially appointed board. This distinction, however, refers only to routine shipboard material inspection. It must be remembered that the Board of Inspection and Survey conducts other types of inspections.

Inspections of ships are conducted by the Board of Inspection and Survey, when directed by CNO, to determine their material condition. Their inspection usually takes place four to six months before regular overhaul. Whenever practical, such inspections are held sufficiently in advance of a regular overhaul of the ship so as to include in the overhaul all the work recommended by the Board following the inspection. Upon the completion of its inspection, the Board reports the general condition of the ship and its suitability for further naval service, together with a list of the repairs, alterations, and design changes which, in its opinion, should be made.

ACCEPTANCE TRIALS AND INSPECTIONS

Trials and inspections are conducted by the Board of Inspection and Survey on all ships before final acceptance for naval service to determine whether or not the contract and authorized changes thereto have been satisfactorily fulfilled. The builder's trials and acceptance trials are usually conducted before a new ship is placed in commission. After commissioning, a final contract trial is held. Similar inspections are made on ships that have been converted to other types. All material, performance, and design defects and deficiencies found, either during the trials or as a result of examination at the completion of trials, are reported by the Board, together with its recommendations as to the responsibility for correction of defects and deficiencies. The Board also recommends any changes in design which it believes should be made to the ship itself or other ships of its type. These recommendations are made to the Secretary of the Navy.

Unless war circumstances prevent it, an acceptance trial takes place at sea over an established trial course. The tests include full power runs ahead and astern, quick reverse, boiler overload, steering, and anchor engine tests. During the trial, usually the builder's personnel operate the ship and its machinery. Ship's personnel who are on board to observe the trial carefully inspect the operation and material condition of machinery and equipment. They note all defects or deficiencies and bring them to the attention of the division or engineer officer so that each item can be discussed with the appropriate members of the Board of Inspection and Survey.

SURVEY OF SHIPS

Survey of a ship is conducted by the Board of Inspection and Survey whenever a ship is deemed by CNO to be unfit for further service because of material condition or obsolescence. The Board, after a thorough inspection, renders an opinion to the Secretary of the Navy as to whether the ship is fit for further naval service or can be made so without excessive cost.

When the Board believes that the ship is unfit for further naval service, the Board makes appropriate recommendations as to the ship's disposition.

SHIP TRIALS

There are a number of different types of trials which are carried out under specified conditions. A list including most of them is given here.

1. Builder's trial
2. Acceptance trials
3. Final contract trials
4. Postrepair trials
5. Laying up or preoverhaul trial
6. Recommissioning trials
7. Standardization trials
8. Tactical trials
9. Full power trials
10. Economy trials

The trials that are considered to be routine ship's trials are numbers 4, 9, and 10 of the above list. Postrepair, full power, and economy trials are the only ones discussed in this chapter, but information on the other types of trials can be found in *Naval Ships' Technical Manual*, chapter 094.

POSTREPAIR TRIAL

The postrepair trial should be made whenever the machinery of a vessel has undergone extensive overhaul, repair, or alteration, which may affect the power or capabilities of the ship or the machinery. A postrepair trial is usually made when the ship has completed a routine naval shipyard overhaul period; the trial is OPTIONAL whenever machinery has undergone only partial overhaul or repair. The object of this trial is to ascertain if the work has been satisfactorily completed and efficiently performed and if all parts of the machinery are ready for service.

The postrepair trial should be held as soon as practical after the repair work has been completed, the preliminary dock trial made, and the persons responsible for the work are satisfied that the machinery is, in all respects, ready for a full power trial. The conditions of the trial are largely determined by the character of the work that has been performed. The trial should be conducted in such manner as the commanding officer and commander of the shipyard may deem necessary. A full power trial is not required in cases where repairs have been slight and the commanding officer is satisfied that they have been satisfactorily performed and can be tested by other means.

Any unsatisfactory conditions found to be beyond the capacity of the ship's force should be corrected by the naval shipyard. When necessary, machinery should be opened up and carefully inspected to determine the extent of any injury, defect, or maladjustment which may have appeared during the postrepair trial.

A certain number of naval shipyard personnel—technicians, inspectors, and repairmen—accompany the ship on a postrepair trial. They check the operation of machinery that has been overhauled by the yard. If a unit of machinery does not operate properly, the yard technicians carefully inspect it to determine the cause of unsatisfactory operation.

FULL POWER AND ECONOMY TRIALS

Trials are necessary to test engineering readiness for war. Except while authorized to disable or partially disable, ships are expected to be able to conduct prescribed trials at any time. Ships normally should be allowed approximately a 2-week period after tender overhauls and a 1-month period after shipyard overhaul to permit final checks, tests, and adjustments of machinery before being called upon to conduct competitive trials.

Trials are also held from time to time to determine machinery efficiency under service conditions, the extent, if any, of repairs necessary, the sufficiency of repairs, and the most economical rate of performance under various conditions of service.

INSPECTIONS AND TESTS BEFORE TRIALS

The full power and the economy trials, as discussed in this chapter, are considered in the nature of competitive trials. It is assumed that the ship has been in full operational status for sufficient time to be in a good material condition and to have a well-trained crew.

Before the full power trial, inspections and tests of machinery and equipment should be made to ensure that no material item will interfere with the successful operation of the ship at full power. The extent of the inspections and the tests will largely depend upon the recent performance of the ship at high speeds, the material condition of the ship, and the time limits imposed by operational commitments.

Not later than one day before a trial, the engineer officer must report to the commanding officer the condition of the machinery, stating whether or not it is in proper condition and fit to proceed with the trial.

GENERAL RULES FOR TRIALS

During all full power trials and during other machinery trials, the following general rules should be observed.

1. Before a power trial, the machinery should be thoroughly warmed up; this can be accomplished by operating at a high fractional power.
2. The speed of the engines should be gradually increased to the speed specified for the trial.
3. The machinery should be operated economically, and designed pressures, temperatures, and number of revolutions must not be exceeded.
4. The full power trial should not be conducted in SHALLOW WATER, which is conducive to excessive vibration, loss of speed, and overloading of the propulsion plant.
5. If a full power trial should continue beyond the length originally specified, then all observations should be continued until the trial is finished.
6. The trial should be continuous and without interruption. If a trial at a constant rpm must be discontinued for any reason, that trial should be considered unsatisfactory and a new start made.
7. No major changes of the plant setup or arrangement should be made during economy trials.

UNDERWAY REPORT DATA

Reports of trials include all the attending circumstances, especially draft forward, draft aft, mean draft, and corresponding displacement of the ship at the middle of the trial; the condition of the ship's bottom; the last time the ship was dry-docked; the consumption of fuel per hour; the average speed of the ship through the water; and the average revolutions of the propelling engines. The methods by which the speed was determined should also be described.

Reports should also include tabulations of gage and thermometer readings of the machinery in use and the revolutions or strokes of pertinent auxiliaries. The auxiliaries in use during the trial should be stated. Each report should state whether the machinery is in a satisfactory condition. If the machinery's condition is found to be unsatisfactory, all defects and deficiencies should be fully described and recommendations made for correcting them.

TRIAL REQUIREMENTS

Trial requirements for each ship cover the rpm for full power at various displacements and injection temperatures. They are furnished to commanders and units concerned by the Chief of Naval Operations (Operations Readiness Division).

As far as reports are concerned, full power trials are of 4 hours duration. The usual procedure is to operate the ship at full power for a sufficient length of time until all readings are constant, and then start the official 4-hour trial period. Economy trials are of six hours duration, a different speed being run at each time a trial is made.

Once scheduled, trials should be run unless prevented by such circumstances as the following:

1. Weather conditions which might cause damage to the ship
2. Material troubles which force the ship to discontinue the trial
3. Any situation where running or completing the trial would endanger human life

If a trial performance is UNSATISFACTORY, the ship concerned will normally be required to hold a retrial of such character as the type commander may consider appropriate.

The fact that a ship failed to make the required rpm for any hour during the trial, and the amount by which it failed, should be noted in the trial report.

OBSERVATION OF TRIALS

When full power trials are scheduled, observing parties are appointed from another ship whenever practical. When a ship is scheduled to conduct a trial while proceeding independently between ports or under the other conditions where it is considered impractical to provide observers from another ship, the ship under trial may be directed to appoint the observers.

The number of personnel assigned to an observing party varies according to size and type of ship. The duties of the observing party are usually as follows:

1. The chief observers organize, instruct, and station the observing party. They check the ship's draft, either at the beginning of the trial or before leaving port; supervise the performance of the engine room observers; check the taking of counter readings; render all decisions following current directives; and check and sign the trial reports.
2. The assistant chief observers assist the chief observers as directed; supervise the performance of the observers; check the taking of fuel oil soundings and meter readings; and make out the trial reports.
3. Assistant observers take fuel soundings, meter readings, counter readings, the ship's draft, and collect all other data that may be required for the trial reports.

The following items should be accomplished or considered before the trial is started.

1. When requested by the observing party, the ship under trial should provide or designate a suitable signaling system so that fuel soundings and the readings of counters and meters may be taken simultaneously.
2. The ship under trial should furnish the chief observer with a written statement of the date of last undocking and the authorized and actual settings of all main machinery safety devices and dates when last tested.
3. The ship should have its draft, trim, and loading conform to trial requirements. In case a least draft is not specified, the liquid loading should equal at least 75 percent of the full load capacity.
4. The chief observer should determine draft and trim before and after the trial, verify the amount of fuel on board, and correct the amount of time at the beginning of the trial. The draft observer should also determine the rpm required for the full power trial at the displacement and injection temperature existing at the start of the trial.
5. The observing party should detect and promptly correct any errors in recording data, since it is important that the required data be correct within the limits of accuracy of the shipboard instruments.
6. The chief observer should instruct members of the observing party to detect any violation of trial instructions, of instructions in the *Naval Ships' Technical Manual*, or of good engineering practice, and then verify any such report and provide the commanding officer a detailed account of each violation.

MANNER OF CONDUCTING TRIALS

Some of the requirements in regards to the manner of conducting full power and economy trials are as follows:

1. Unless otherwise ordered, a full power trial may be started at any time on the date set.

2. The trial should be divided into hourly intervals, but readings should be taken and recorded every half hour. Data are submitted as hourly readings in the trial report.
3. Fuel expenditures for each hourly interval of the trial should be determined by the most accurate means practical, normally by meter readings corrected for meter error and verified by soundings.
4. The appropriate material condition of the ship should be set during the different trials.
5. During all trials, the usual "housekeeping" and auxiliary loads should be maintained. The minimum services provided should include normal operation of the distilling plant, air compressor, laundry, galley, ventilation systems, elevators (if installed), and generators for light and power under load conditions similar to those required for normal operations at similar speeds under the prescribed material condition.
6. All ships fitted with indicators, torsion meters, and other devices for measuring shaft or indicated horsepower should make at least two observations during the full power trial to determine the power being developed.
7. The chief observer's report of the trial should state whether all rules for the trial have been complied with.

There are special forms used for full power and economy trial reports. Illustrations of these forms are not given in this training manual, but you can obtain copies from your log room and, in this way, get an idea of the data and readings that are required for full power and economy trials.

Trial forms, and such items as tachometers, stopwatches, and flashlights, should be available to the observing party and to the personnel who take the readings. Any gages or thermometers, which are considered doubtful or defective, should be replaced before trials are held. A Quartermaster must check and adjust all clocks in the engineering spaces and on the bridge before any trials are held.

Careful inspections and tests of equipment and items of machinery must be made that may cause difficulties during full power operation, since it is possible that unknown defects or conditions may go undetected during operation at fractional powers—the normal operating condition of the ship most of the time.

A common practice among many commanding officers, when making full power trials, is first to bring the ship up to a speed of one or more knots below the trial run speed of the ship and then turn the control of the speed (except in cases of emergency nature) over to the engineer officer. The control engine room, under the supervision of the engineer officer, brings the speed up slowly, depending upon the conditions of the plant, until the specified speed has been reached.

NOISE POLLUTION INSPECTIONS

Hearing loss problems have been and continue to be a source of concern within the Navy, both ashore and afloat. In the Navy the loss of hearing can occur from exposure to impulse or blast noise (that is, gunfire, rockets, and so forth) or from continuous or intermittent sounds such as jet or propeller aircraft, marine engines, boiler equipment operations, and any of a myriad of noise sources associated with industrial activities (such as shipyards). Hearing loss may be temporary and will disappear after a brief period of nonexposure, or it may become permanent through repeated exposures to intense noise levels. The loss of hearing sensitivity is generally in the higher frequencies of 4,000 to 6,000 hertz (Hz) with many people sustaining extensive impairment before the all important speech range of 500 to 3,000 Hz is appreciably affected.

The Navy recognized noise pollution to be a problem and started to combat it through the Hearing Conservation Program. The main purpose of this program is to establish and implement an effective occupational noise control and hearing conservation program which has as its goal the elimination/prevention of hearing loss.

HEARING CONSERVATION PROGRAM

Hearing loss associated with exposure to hazardous noise and the high cost of compensation claims have highlighted a significant problem which requires action to reduce or eliminate hazardous occupational noise levels. An effective occupational noise control and hearing conservation program will prevent or reduce the exposure of personnel to potentially hazardous noise. Such programs will incorporate the following elements:

1. Identification of hazardous noise areas and their sources
2. Elimination or reduction of noise levels through the use of engineering controls
3. Periodic hearing testing of noise-exposed personnel to evaluate program effectiveness
4. Education of all hands in the command's program and their individual responsibilities
5. Strict enforcement of all prescribed occupational noise control and hearing conservation measures including disciplinary action for violators and supervisors, as necessary

RESPONSIBILITIES

The Secretary of the Navy policy, contained in SECNAVINST 5100.1D, emphasizes that occupational safety and health are the responsibilities of all commands. Accordingly, the following actions and responsibilities are assigned.

Naval Medical Command (BUMED)

The Commander of the Naval Medical Command must manage the hearing conservation program and maintain the program's currency and effectiveness. It must provide audiometric support to all military and civilian personnel who are included in a hearing conservation program, professional and technical assistance to commands responsible for assuring that the hearing of military and civilian personnel is protected, and appropriate professional and technical hearing conservation guidance and assistance to the Chief of Naval Education and Training (CNET).

It must develop guidelines and issue certifications following OPNAVINST 6260.2 enclosure for (1) personnel conducting sound level measurements, (2) personnel performing hearing conservation audiometry, (3) audiometric test chambers, (4) audiometers, and (5) all sound level measuring equipment. It must support a research and development effort in medical aspects of hearing conservation to ensure existing technology represents the most advanced state of the art.

Chief of Naval Material

The Chief of Naval Material (CHNAVMAT) must, in coordination with CHBUMED, provide technical assistance and engineering guidance to commands as delineated in OPNAVINST 6260.2 and periodically update to maintain currency and effectiveness. It must ensure consistent and required military capabilities, and that noise abatement is considered, designed, and engineered into all (both existing and future) ships and aircraft, weapons and weapon systems, equipment, materials, supplies, and facilities which are acquired, constructed, or provided through the Naval Material Command; and it must provide appropriate technical and engineering control methodology guidance and assistance to CNET.

The Chief, Naval Education and Training

The Chief of Naval Education and Training (CNET) must, with the assistance of CHBUMED and CHNAVMAT, incorporate hearing conservation and engineering control guidance information in the curricula of all appropriate training courses. It must provide specialized hearing conservation and engineering control training and education, as required, and serve as the central source for the collection, publication, and dissemination of information on specialized hearing conservation and engineering control training courses.

Naval Inspector General

The Naval Inspector General (NAVINSGEN) must evaluate hearing conservation and engineering control procedures during conduct of the Navy's Occupational Safety and Health Inspection Program (NOSHIP) oversight inspections of activities ashore.

President, Board of Inspection and Survey

The President of the Board of Inspection and Survey (PRESINSURV) must be directly responsible for oversight inspection aspects of shipboard hearing conservation and engineering control compliance. Inspections of fleet units must be incorporated into existing condition inspection programs.

Commander, Naval Safety Center

The Commander of the Naval Safety Center (COMNAVSAFECEN) must provide program evaluation, as requested, provide program promotion through NAVSAFECEN publications, and review program compliance during the conduct of surveys.

Fleet Commander in Chief

Fleet Commanders in Chief and other major commanders, commanding officers, and officers in charge must ensure that all Navy areas, work sites, and equipment under their responsibiity are identified as potentially hazardous and labeled following OPNAVINST 6260.2 where noise levels are 85 dBA or greater or where impulse or impact noise exceeds a peak sound pressure level of 140 dB. Where necessary, surveys must be conducted in compliance with the guidance outlined in OPNAVINST 6260.2 enclosure (1). Enclosure (3) of OPNAVINST 6260.2 provides a listing of activities where industrial hygiene assistance may be obtained.

Where a potential noise hazard has been identified, a hearing conservation program must be instituted following OPNAVINST 6260.2, and a roster will be maintained on personnel placed in the program. Noise levels will be eliminated or reduced through the use of engineering controls.

Personal hearing protective devices will be provided and used properly by personnel where administrative or engineering controls are infeasible or ineffective. All military civilian personnel whose duties entail exposure to potentially hazardous noise will receive instruction regarding the command occupational noise control and hearing conservation programs, the undesirable effects of noise, the proper use and care of hearing protective devices, and the necessity of periodic hearing testing. Emphasis will be placed upon leadership by example as regards the wearing of hearing protective devices. Command policy must be enforced, including the initiation of disciplinary measures for repeated failure to comply with the requirements of the hearing conservation program.

In addition to the personnel mentioned above, we need to describe the shipboard responsibilities of the Engineer Officer and the work center supervisor.

Engineer Officer

OPNAVINST 6260.2 outlines the shipboard program for hearing conservation. Although the medical department representative has primary responsibility over this program, there are elements that the engineer officer must monitor and which are subject to periodic review. Periodic surveys must be accomplished to properly identify those areas within the propulsion spaces that fall into the category "Noise Hazardous Area." These areas must be marked, and personnel tasked with working in these areas must have available to them and use the prescribed aural protective devices. Training and discussion should emphasize the need for wearing these devices and should stress the medical elements of hazards to hearing resulting from "nonuse." The following paragraphs outline the specific actions to be taken by the engineer officer and subordinates to ensure the effectiveness of the command program.

The engineer officer will do the following:

1. Ensure that all newly reporting personnel have received a baseline audiogram and that each individual's medical record reflects the results of this examination.
2. Ensure that all engineering department personnel receive an annual reexamination by a medical activity.
3. Advise the medical department representative, by memorandum, of personnel by name who are working or standing watches in areas determined to be "high noise areas" and defined in OPNAVINST 6260.2.

4. Arrange for a noise survey to be taken initially by an industrial or IMA activity, and ensure that surveys are retaken at least annually.

5. Designate "high noise areas" from the survey and ensure that areas are properly marked or labeled with prescribed markings. Advise the medical department of areas so designated and of any changes that may occur.

6. Issue aural protective devices to all personnel tasked to work in designated "high noise areas." These devices will be made available through the medical department for individual fitting and issue. Issue of these devices will be recorded in the individuals' medical records.

7. Ensure that sufficient training is provided to operating personnel concerning the hazards and preventive elements of the program, stressing the use of available protective devices.

8. The main propulsion assistant should be designated as the department officer to monitor and assist the engineer officer in all elements of the program.

Work Center Supervisor

As a work center supervisor, you are responsible for ensuring that safety signs are posted in your spaces which are high noise areas, that your personnel are trained and counseled as to the effects of noise pollution, and that they have the proper hearing protection as required for that area.

For additional information on the Hearing Conservation Program, refer to OPNAVINST 6260.2.

QUALITY ASSURANCE PROGRAM

The quality assurance program was established by Commander, Naval Surface Force, U.S. Atlantic Fleet, to provide personnel with information and guidance necessary to administer a uniform policy of maintenance and repair of ships.

The *Quality Assurance (QA) Manual* 9090.1 sets forth minimum quality assurance requirements. Where more stringent requirements are imposed by higher authority, such requirements must have precedence. Where conflict exists with previously issued COMNAVSURFLANT letters and transmittals, this manual must have precedence. Such conflicts should be reported to COMNAVSURFLANT.

The instructions contained in the QA Manual apply to *every ship and activity* of the force. It is primarily applicable to the repair/maintenance accomplished by the force Intermediate Maintenance Activities (IMA). The requirements are also applicable to ship's force when maintenance is performed on their own ship. In all cases, specifications must be met, and if such is not the case, then a Departure from Specifications Request must be recorded and reported. Departures from specifications must also be reported to appropriate levels so that departure approvals or restrictions may be issued.

Because of the wide range of ship types and equipments and the varied resources available for maintenance and repair, the instructions set forth in this manual are necessarily somewhat general in nature. Each activity must implement a quality assurance program to meet the intent of this manual. Repairs in conformance with specifications is the goal.

SHIP QUALITY CONTROL INSPECTORS

As a work center supervisor you will be responsible for the Quality Control Program in your work spaces. You must do the following:

1. Develop a thorough understanding of the QA Program.
2. Inspect all work for conformance to specifications.
3. Train personnel in quality control.
4. Maintain ship records to support the QA Program following the QA Manual.
5. Ensure only calibrated equipment is used in acceptance testing and/or inspection of work.
6. Initiate Departure from Specification Report (QA Form 12) when required.
7. Ensure all inspection beyond their capabilities are performed and accepted by IMA before final acceptance/installation of the product by ship.
8. Witness and document all tests.
9. Ensure adequate overload, overpressure, and so forth, protection is provided for all tests.

10. Ensure all material or test results which fail to meet specifications are recorded and reported.

11. Report all deficiencies/discrepancies to the engineer through ships QA coordinator keeping his division officer informed.

12. Develop controlled work packages for all ship repair work requiring QA controls.

STEERING INSPECTIONS

1. Ships must inspect steering systems following PMS requirements.

2. Routine steering gear inspections must be performed by an IMA annually and before major deployment.

3. IMA steering inspections must be accomplished using a Steering Gear Inspection Report, similar to those in annex C and D, for the applicable class of ship.

a. One copy of this report must be maintained by the IMA QA Office for one audit year, two copies will be delivered to the inspected ship's chief engineer, and one copy must be submitted to COMNAVSURFLANT for review.

b. COMNAVSURFLANT must monitor copies of all completed steering inspection reports for compliance to specification and this section.

4. IMA steering gear inspection teams must consist of the following personnel:

a. Machinist's Mate E-5 or above
b. Electrician's Mate E-5 or above
c. Verifying officer

(1) The inspecting machinist's mate should be provided with training in basic hydraulics.

(2) When you select initial inspection teams, care should be taken to choose those personnel who will be available to remain on the team for a reasonable length of time (1-year minimum). These people will then be available to train the new team members as normal turnover occurs.

(3) Proof of steering inspectors qualifications must be provided to QA personnel, QA auditors, inspected ship personnel, and so forth.

(4) Steering inspectors must demonstrate knowledge of the specifications, requirements of steering systems, and their inspections through applicable Navy schools, written exams, and on-the-job training as applicable.

ELECTRICAL INSPECTIONS

Electrical inspections must be made following the applicable NSTM, PMS requirement, or technical directives.

1. Electric motor repair and/or rewind incoming, in-process, and final inspection must be made following *Naval Ships' Technical Manual*, chapter 300 and NAVSEA 0900-LP-060-2010 and 2020. Tests and inspections must be documented on the forms required by these documents.

2. All other electrical tests and inspections, such as quarterly gyro inspections, motion picture projector inspections, and small boat inspections, must be documented on the test and inspection forms required by technical directives. If guidance is not available, use QA Forms 17, 17A, and 51, as applicable.

MAINTENANCE AND MATERIAL MANAGEMENT SYSTEMS (3-M SYSTEMS)

The primary objective of the Navy Ship's Maintenance and Material Management Systems (3-M Systems) is to provide for managing maintenance and maintenance support in a manner which will ensure maximum equipment operational readiness. OPNAVINST 4790.4A, volumes I, II, and III, contains all of the detailed procedures and instructions for the effective operation of the 3-M Systems. Other instructions on the 3-M Systems are found in the type commander's maintenance manuals.

This section of the chapter will discuss the most common records of the 3-M Systems that must be kept current in the engineering department.

PLANNED MAINTENANCE SCHEDULES

In an effective Planned Maintenance System (PMS) Program, careful attention must be given to the PMS schedules to ensure that they are accurately filled out and posted in a timely manner. PMS schedules are categorized as cycle, quarterly, and weekly.

Cycle Schedule

The Cycle PMS Schedule displays the planned maintenance requirements to be performed between major overhauls of the ship. The following information must be filled in on the cycle schedule: ship's name and hull number, work center designator code, maintenance index page (MIP) number, component or systems name, and maintenance scheduled in each quarter after overhaul.

The engineer officer must supervise all cycle scheduling of engineering departmental maintenance, then sign and date the Cycle PMS Schedule before it is posted.

If the need to rewrite the Cycle PMS Schedule arises, the old schedule should be filed with the last quarterly schedule with which it was used.

Quarterly Schedule

The Quarterly PMS Schedule is a visual display of the work center's PMS requirements to be performed during a specific 3-month period. Spaces are provided for entering the work center, quarter after overhaul, department head's signature, data prepared, and the months covered. Thirteen columns, one for each week in the quarter, are available to permit scheduling of maintenance requirements on a weekly basis throughout the quarter. There are also columns to enter the MIP number and PMS requirements that may require rescheduling. There are "tick" marks across the top of the scheduling columns for use in showing the in-port/underway time of the ship for the quarter.

The engineer officer must supervise scheduling of PMS on the quarterly schedule for his/her department, then sign and date the schedule before it is posted. At the end of each quarter, the engineer officer must review the quarterly schedule, check the reasons for PMS actions not accomplished, and sign the form in the space provided on its reverse side. The division officer is responsible for updating the quarterly schedule every week. Completed quarterly schedules should be kept on file for 1 year.

Weekly Schedule

The Weekly PMS Schedule is a visual display of the planned maintenance scheduled for accomplishment in a given work center during a specific week. The weekly schedule is used by the work center supervisor to assign and monitor the accomplishment of required PMS tasks by work center personnel.

The Weekly PMS Schedule contains blank spaces to be filled in for work center code, date of current week, division officer's signature, MIP number minus the date code, component names, names of personnel responsible for specific maintenance items, periodicity codes of maintenance requirements, outstanding major repairs, and situation requirements.

The work center supervisor is responsible for completing the Weekly PMS Schedule and for updating it every day.

SCHEDULING WORK

Careful planning is required to keep up with all maintenance and repair work within your division. You should already have in your work center the necessary items which can help you in scheduling your work. These items are the Quarterly PMS Schedule, the Weekly Schedule, and the Maintenance Data Collection Subsystem (MDCS) Forms, such as the OPNAV 4790/2K, OPNAV 4790/2L, and OPNAV 4790/2Q. Of these, OPNAV Form 4790/2K is used to show completion of specific PMS requirements; to request repair of equipment or services from IMAs or shipyards; or can be used to describe equipment malfunctions. OPNAV Form 4790/2L is a supplemental form which you use to provide amplifying information relating to a maintenance action described on a corresponding 4790/2K. The OPNAV 4790/2L may also be used to list multiple item serial numbers and locations for which identical maintenance requirements exist from an outside activity. It may also be used to list drawings and sketches.

OPNAV Form 4790/2Q is an automated work request produced by an IMA with computer capabilities. The "2Q" is produced from the original 4790/2K which is in your Current Ship's Maintenance Project (CSMP) suspense file. For more detailed information about these forms and schedules and how to fill them out, review OPNAVINST 4790.4A, volumes I and II.

Some of the proven methods you should follow when scheduling maintenance and repair work are listed below.

1. Size up each job before you let anyone start working on it. Check the applicable Maintenance Requirement Cards (MRCs) so that you will know exactly what needs to be done. Also, check all applicable drawings and manufacturer's technical manuals.

2. Check on materials before you start. Be sure that all required materials are available before your personnel start working on any job. Do not overlook small items—nuts, bolts, washers, packing and gasket materials, tools, measuring devices, and so forth. A good deal of labor can be saved by the simple process of checking on the availability of materials before a job is actually started. An inoperable piece of machinery may be useless, but it can become a nuisance and a safety hazard if it is spread around the engine room in bits and pieces while you wait for the arrival of repair parts or materials.

3. Check the priority of the job and that of all other work that needs to be done.

4. When assigning work, you carefully consider the capabilities and experience of your personnel. As a rule, the more complicated jobs should be given to the more skilled and more experienced people. When possible, however, less experienced people should be given difficult work to do under supervision so that they may acquire skill in such jobs.

Be sure that the person who is going to do a job is given as much information as necessary. An experienced person may need only a drawing and a general statement concerning the nature of the job. A less experienced person is likely to require additional instructions and, as a rule, closer supervision.

5. Keep track of the work as it is being done. In particular, check to be sure that proper materials and parts are being used, that the job is properly laid out or set up, that all tools and equipment are being used correctly, and that all safety precautions are being observed.

6. After a job has been completed, make a careful inspection to be sure that everything has been done correctly and that all final details have been taken care of. Check to be sure that all necessary records and reports have been prepared. These job inspections serve at least two important purposes: first, they are needed to make sure that the work has been properly performed; and second, they provide for an evaluation of the skills and knowledge of the person who has done the work. Do not overlook the training aspects of a job inspection. When your inspection of a completed job reveals any defects or flaws, be sure to explain what is wrong, why it is wrong, and how to avoid similar mistakes in the future.

ESTIMATING WORK

You will often be required to estimate the amount of time, the number of personnel, and the amount of material that will be required for specific repair jobs. Actually, you are making some kind of estimate every time you plan and start a repair job as you consider such questions as the following: How long will it take? Who can best do the job? How many people will be needed? Are all necessary materials available?

However, there is one important difference between the estimates you make for your own use and those that you make when your division officer asks for estimates. When you give an estimate to someone in authority over you, you cannot tell how far up the line this information will go. It is possible that an estimate you give to your division officer could ultimately affect the operational schedule of the ship; it is essential, therefore, that such estimates be as accurate as you can possibly make them.

Many of the factors that apply to the scheduling of all maintenance and repair work apply also to estimating the time that will be required for a particular repair job. You cannot make a reasonable estimate until you have sized up the job, checked on the availability of materials, checked on the availability of skilled personnel, and checked on the priority of the various jobs for which you are responsible. To make an accurate estimate of the time required to complete a specific repair job, you must also consider what part of the work must be done by other shops and what kinds of interruptions and delays may occur. Although these factors are also important in the routine scheduling of maintenance and repair work, they are particularly important when estimates of time that may affect the operational schedule of the ship are made.

If part of the job must be done by other shops, you must consider not only the time actually required by these shops but also time that may be lost if one of them holds up your work and the time spent to transport the material between shops. Each shop should make a separate estimate, and the estimates should be combined to obtain the final estimate. Do NOT attempt to estimate the time that will be required by other personnel. Attempting to estimate what someone else can do is risky because you can't possibly have enough information to make an accurate estimate.

Consider all the interruptions that might cause delay, over and above the time required for the work itself. Such things as drills, inspections, field days, and working parties can have quite an effect on the number of people who will be available to work on the job at any given time.

Estimating the number of personnel who will be required for a certain repair job is, obviously, closely related to estimating time. You will have to consider not only the nature of the job and the number of people available but also the maximum number of people who can work EFFECTIVELY on a job or on part of the job at the same time. Doubling the number of personnel will not cut the time in half; instead, it will result in confusion and aimless milling around.

The best way to estimate the time and the number of personnel needed to do a job is to divide the total job into the various phases or steps that will have to be done, and then estimate the time and the personnel required for each step.

Estimating the materials required for a repair job is often more difficult than estimating the time and labor required for the job. Although your own past experience will be your best guide for this kind of estimating, a few general considerations should be noted.

1. Keep accurate records of all materials and tools used in any major repair job. These records serve two purposes: first, they provide a means of accounting for materials used; and second, they provide a guide for estimating materials that will be required for similar jobs in the future.
2. Before starting any repair job, plan the job carefully and in detail. Make full use of manufacturers' technical manuals, blueprints, drawings, and any other available information, and find out in advance all the tools and materials that will be required for the accomplishment of each step of the job.
3. Make a reasonable allowance for waste when calculating the amount of material you will need.

FEEDBACK FORM

The PMS Feedback Report Form, OPNAV Form 4790/7B, provides maintenance personnel with the means to report discrepancies and problems and to request PMS software. All PMS Feedback Reports are sent to NAVSEACENs or TYCOMs, based on the category of the Feedback Report.

Feedback Reports are originated in the work center and must be signed by the originator. They are then screened and signed by the division officer and the engineer officer before being forwarded to the 3-M coordinator. The 3-M coordinator will date and sign the feedback report, serialize it, and return the green copy to the originating work center. The originating work center must file the green copy until an answer to the feedback report is received.

SUMMARY

Now that you have completed this chapter, you have a pretty fair idea of just how many inspections and different types of maintenance we really have. You must bear in mind that most are designed to help you in your work by pointing out problem areas before they become major problems.

REFERENCES

Naval Ships' Technical Manual, Chapter 090

Naval Ships' Technical Manual, Chapter 094

Naval Ships' Technical Manual, Chapter 235

Naval Ships' Technical Manual, Chapter 300

Naval Ships' Technical Manual, Chapter 434

OPNAVINST 4790.4A, Volumes I, II, and III

OPNAVINST 6260.2

Quality Assurance Manual, 9090.1

SECNAVINST 5100.1D

CHAPTER 3

ENGINEERING CASUALTY CONTROL

The operating efficiency of a ship depends largely on the ability of the engineering department to continue its services both during normal operations and during casualties. Casualty control is concerned with the prevention, minimization, and correction of the effects of operational and battle casualties. Casualties are used in this chapter as defined in chapter 079-V2 of *Naval Sea Technical Manual*.

In this chapter, we shall discuss casualty prevention, training, and restoration. These actions provide a ship with a well rounded casualty control program.

CASUALTY PREVENTION

Casualty prevention is the most effective phase of casualty control. It concerns the quality of preventive maintenance on machinery and systems as an effort toward counteracting the effects of operational and battle casualties. Proper preventive maintenance will greatly reduce the occurrence of casualties caused by material failures. Continuous detailed inspection procedures are necessary. These are necessary not only to disclose partially damaged parts that may fail at a critical time, but also to eliminate the underlying conditions that cause them. This includes misadjustment, improper lubrication, and corrosion. These conditions are detrimental to machinery and cause early failure.

Casualty prevention requires constant training. Casualty control training must be a continuous step-by-step procedure. It should provide for study time and refresher drills. Any realistic simulation of casualties must be preceded by adequate preparation. You must impress upon your watch sections the full consequences of any error which may be made in handling real or simulated casualties.

Most engineering plant casualties are caused by lack of knowledge of correct procedures on the part of watch station personnel. Often a simple problem, if allowed to compound itself, may lead to the disabling of the ship. Causes of ineffective casualty control and their prevention are listed below.

1. Lack of positive control. The engineering officer of the watch (EOOW) must maintain positive control of every situation that arises. This individual must possess thorough knowledge of the correct procedures and systems operation.
2. Lack of effective communications. Communications throughout the engineering plant must be maintained at all times. The repeat back technique for watch standers is the only means of ensuring that communications are received and understood.
3. Lack of systems knowledge. Watch personnel are frequently shallow in their depth of systems knowledge and approach to casualty control. Watch sections must be familiar with the theory and operation of all vital engineering systems.
4. Lack of casualty control assistance. Off-watch personnel are not called to assist in casualty control follow-up actions with the result that watch standers are unable to satisfactorily deal with recovering from a casualty. Off-watch personnel must be called to provide necessary expertise and augment assigned watch standers performing restoration actions.

In the past, primary emphasis in casualty control training was placed on speed. However, with the development and implementation of the Engineering Operational Casualty Control (EOCC) portion of the Engineering Operational Sequence System (EOSS), there has been a more methodical and organized approach to casualty control. This has resulted in increased control, decreased plant disablements, and increased overall safety to plants and personnel. EOCC and EOSS will be discussed in more detail later.

A ship must be self-sufficient in conducting propulsion plant casualty control drills in order to ensure maximum engineering department operational readiness. The management required for such drills involves the establishment of the Engineering Casualty Control Evaluation Team (ECCET). Preliminary administrative support for the training program must also be established.

ENGINEERING CASUALTY CONTROL EVALUATION TEAM (ECCET)

An ECCET should be developed for each underway watch section. Also, a sufficient number of personnel should be assigned to evaluate each watch station during the drills.

The engineer officer must ensure the development of an accurate, comprehensive drill package. It should be adequate to exercise the engineering department in all phases of casualty control procedures. The drill package should contain a complete file of drill scenarios and drill cards for each type of casualty that could possibly occur to the propulsion plant. Scenarios should contain the following information:

1. Drill title
2. Scenario number (if assigned)
3. A general description of the casualty
4. The method of imposing the drill
5. The cause (several causes should be listed if plausible)
6. Estimated time of repair (ETR)
7. Cautions to prevent personnel hazards or machinery damage
8. Any simulations to be used in the drill

The drill cards must give the correct procedure to be followed by each watch team member. This procedure should be in the proper sequence for the drill. The purpose of the drill cards is to give the ECCET members ready reference to procedures to be followed. The engineer officer must ensure that adequate research is done to ensure the accuracy of each scenario. EOCC, if installed, should be the prime information source. The main propulsion assistant (MPA) should have custody of a master drill card package. This package should have appropriate copies of applicable drill scenarios. It should also include drill cards for each space.

The planning and scheduling of casualty control drills should receive equal priority with other training evolutions conducted during normal working hours. When a specified time for the conduction of casualty control drills is authorized by the commanding officer, the engineer officer must prepare a drill plan. Careful preplanning and sequencing of events are mandatory.

After the proposed drill plan is approved by the commanding officer, designated ECCET personnel meet. This ensures that members of the team understand the procedures and the sequencing of events. In preparing the drill plan, consideration is given to the following items:

1. General condition of the engineering plant
2. Machinery and safety devices out of commission
3. Length of time set aside for the drill
4. State of training of the watch section
5. Power to be provided to vital circuits

Within the constraints of the items listed above, first priority on drill selection is given to boiler casualty drills and propulsion space fire drills. These drills represent the greatest danger. They involve the largest number of propulsion plant watch team personnel. Second priority is given to lube oil system casualties. This is because of the inherent danger to main and auxiliary equipments that these casualties represent. Third priority is given to other main engine casualties. In selecting drills, the engineer officer must give emphasis to the development of watch team proficiency in handling priority one casualties.

Normally, ECCET members arrive on station shortly before the drills commence. They ensure that communications are established throughout the plant. With the officer of the deck's (OOD's) permission, the drill initiator imposes a casualty according to the drill plan. With regard to safety of personnel and equipment, drills are conducted as realistically as possible. Simulations are kept to an absolute minimum. Any time a hazardous situation develops, ECCET members assist the watch section in restoring the plant to proper operation. ECCET members also complete a drill critique form during the course of the drill.

As soon as possible, following the drill, a critique is conducted. Personnel of the applicable watch section attend. ECCET members and the engineer officer also attend. The ECCET leader gives the result of the drill. All other ECCET members then read their drill critique forms. Drills are evaluated as satisfactory or unsatisfactory by the ECCET leader. This is based on a review of the critique sheets before the critique. The following deficiencies form a basis for a finding of unsatisfactory.

1. Loss of plant control by the EOOW or space supervisor when either is unaware of overall plant status. It is also unsatisfactory if they are unable to restore the plant to a normal operating condition utilizing EOSS/EOCC or other issued casualty control procedures.
2. Safety violations which may cause a hazard to personnel or result in serious machinery derangement.
3. Significant procedural deficiencies which indicate a lack of knowledge of the proper procedures to be followed in correcting a casualty.

ENGINEERING OPERATIONAL SEQUENCING SYSTEM (EOSS)

The Navy has developed a system known as the Engineering Operational Sequencing System (EOSS). Essentially, the EOSS is to the operator as PMS is to the maintainer.

Main propulsion plants in ships of today's modern Navy are becoming more technically complex as each new class of ship is built and joins the fleet. Increased complexity requires increased engineering skills for proper operation. Ships that lack the required experienced personnel have had material casualties. These casualties have jeopardized their operational readiness. Rapid turnover of engineering personnel who man and operate the ships further compounds the problem of developing and maintaining a high level of operator and operating efficiency.

The Navy has been increasingly aware of these problems. Studies have been done to evaluate the methods and procedures presently used in operating complex engineering plants. The results of these studies have shown that in many instances sound operating techniques were not followed. Some of the circumstances found to be prevailing in engineering plants are described below.

- The information needed by the watch stander was usually scattered throughout publications which were generally not readily available.

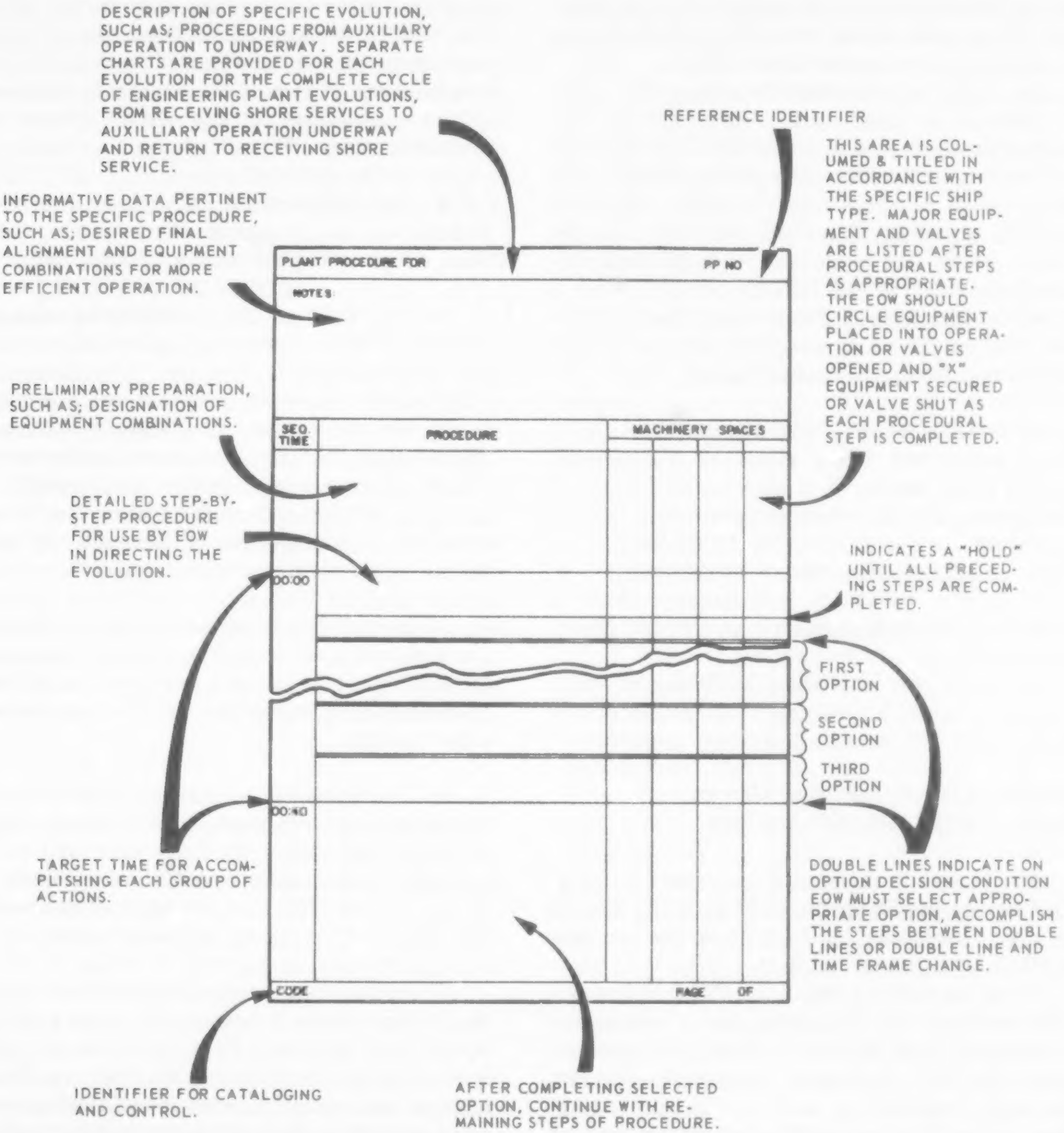
- The bulk of the publications were not systems oriented. Reporting engineering personnel had to learn specific operating procedures from "old hands" presently assigned. Such practices could ultimately lead to misinformation or degradation of the transferred information. These practices were costly and resulted in nonstandard operating procedures, not only between adjoining spaces but also between watch sections within the same space.

- Posted operating instructions often did not apply to the installed equipment. They were conflicting or incorrect. No procedures were provided for aligning the various systems with other systems.

- The light-off and securing schedules were prepared by each ship and were not standardized between ships. The schedules were written for general, rather than specific, equipment or system values. They did not include alternatives between all the existing modes of operation.

Following these studies, NAVSEA developed the EOSS, which is designed to help eliminate operational problems. EOSS involves the participation of all personnel from the department head to the watch stander. The EOSS consists of a set of systematic and detailed written procedures. The EOSS utilizes charts, instructions, and diagrams. These are developed specifically for the operational and casualty control function of a specific ship's engineering plant.

EOSS is designed to improve the operational readiness of the ship's engineering plant. It does this by increasing its operational efficiency and providing better engineering plant control. It also reduces operational casualties and extends the equipment life. These objectives are accomplished by first defining the levels of control; second, by operating within the engineering plant; and lastly, by providing each supervisor and operator with the information needed. This


DESCRIPTION OF SPECIFIC EVOLUTION, SUCH AS; PROCEEDING FROM AUXILIARY OPERATION TO UNDERWAY. SEPARATE CHARTS ARE PROVIDED FOR EACH EVOLUTION FOR THE COMPLETE CYCLE OF ENGINEERING PLANT EVOLUTIONS, FROM RECEIVING SHORE SERVICES TO AUXILLIARY OPERATION UNDERWAY AND RETURN TO RECEIVING SHORE SERVICE.
REFERENCE IDENTIFIER
THIS AREA IS COLUMED & TITLED IN ACCORDANCE WITH THE SPECIFIC SHIP TYPE. MAJOR EQUIPMENT AND VALVES ARE LISTED AFTER PROCEDURAL STEPS AS APPROPRIATE. THE EOW SHOULD CIRCLE EQUIPMENT PLACED INTO OPERATION OR VALVES OPENED AND "X" EQUIPMENT SECURED OR VALVE SHUT AS EACH PROCEDURAL STEP IS COMPLETED.
INFORMATIVE DATA PERTINENT TO THE SPECIFIC PROCEDURE, SUCH AS; DESIRED FINAL ALIGNMENT AND EQUIPMENT COMBINATIONS FOR MORE EFFICIENT OPERATION.
PLANT PROCEDURE FOR
PP NO
NOTES:
PRELIMINARY PREPARATION, SUCH AS; DESIGNATION OF EQUIPMENT COMBINATIONS.
SEQ TIME
PROCEDURE
MACHINERY SPACES
DETAILED STEP-BY-STEP PROCEDURE FOR USE BY EOW IN DIRECTING THE EVOLUTION.
00:00
INDICATES A "HOLD" UNTIL ALL PRECEDING STEPS ARE COMPLETED.
FIRST OPTION
SECOND OPTION
THIRD OPTION
00:40
TARGET TIME FOR ACCOMPLISHING EACH GROUP OF ACTIONS.
DOUBLE LINES INDICATE ON OPTION DECISION CONDITION EOW MUST SELECT APPROPRIATE OPTION, ACCOMPLISH THE STEPS BETWEEN DOUBLE LINES OR DOUBLE LINE AND TIME FRAME CHANGE.
CODE
PAGE OF
IDENTIFIER FOR CATALOGING AND CONTROL.
AFTER COMPLETING SELECTED OPTION, CONTINUE WITH REMAINING STEPS OF PROCEDURE.

121.26

Figure 3-1.—Sample plant procedure chart.

is done by putting it in words they can understand at their watch station.

The EOSS is composed of three basic parts.

- *The User's Guide*
- The Engineering Operational Procedures (EOP)
- The Engineering Operational Casualty Control (EOCC)

EOSS User's Guide

The *User's Guide* is a booklet which explains the EOSS package and how it is used to the ship's best advantage. It contains document samples and explains how they are used. It provides recommendations for training the ship's personnel in utilizing the specified procedures.

EOSS documentation is developed using work-study techniques. All existing methods and procedures for plant operation and casualty control procedures are documented. These include the actual ship procedures as well as those procedures contained in available reference sources.

Each action is subjected to a critical examination to evaluate the adequacy of the present procedures. At the completion of this analytic phase, new procedural steps are developed into an operational sequencing system. Step-by-step, time-sequenced procedures and configuration diagrams are prepared to show the plant layout in relation to operational components. The final step in the development phase of an EOSS is a validation on board ship. This is done to ensure technical accuracy and adequacy of the prepared sequencing system. All required corrections are made. They are then incorporated into the package before installation aboard ship.

The resulting sequencing system provides the best tailored operating and engineering operational casualty control procedures available pertaining to a particular ship's propulsion plant. Each level is provided with the information required to enable the engineering plant to respond to any demands placed upon it.

Engineering Operational Procedures (EOP)

The operational portion of the EOSS contains all information necessary for proper operation of a ship's engineering plant. It also contains guides for scheduling, controlling, and directing plant evolutions through operational modes from receiving shore services, to various modes of in-port auxiliary plant steaming, to underway steaming.

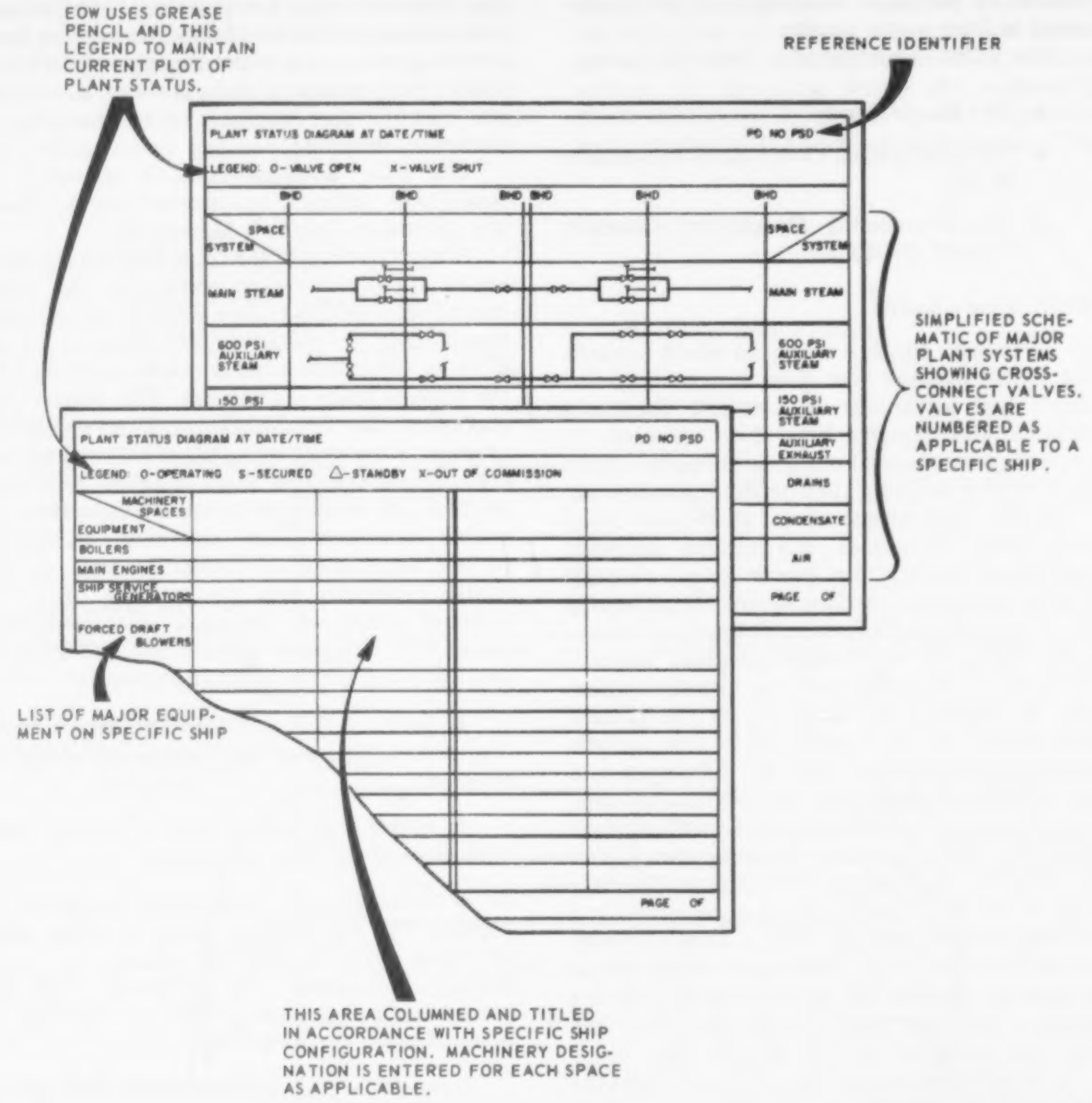
The EOP documentation is prepared for specifically defined operational stages. These are defined as Stages I, II, and III.

Stage I deals with the total engineering plant under the direct responsibility of the plant supervisor (EOOW). The EOOW coordinates the placing in operation and securing of all systems and components normally controlled by the various space supervisors. This person also supervises those functions which affect conditions internal to the engineering plant such as jacking, testing, and spinning main engines. The EOP documentation assists the plant supervisor to ensure optimum plant operating efficiency, proper sequencing of events in each operational evolution, and the training of newly assigned personnel. During a plant evolution, the EOOW designates control and operation of the following systems and components:

- Systems that interconnect one or more engineering plant machinery spaces and electrical systems.
- Major components such as boilers, main engines, and electrical generators.
- Systems and components required to support the engineering plant or other ship functions such as distilling plants, air compressors, fire pumps, and auxiliaries which are placed in operation or secured in response to demand upon their services.

To assist the plant supervisor with these operations, the EOP section provides the following documents:

- Index pages listing each document in the Stage I station book by identification number and title.
- Plant procedure charts (fig. 3-1) providing step-by-step procedures for each engineering plant evolution. The example used in this section illustrates the types of EOSS charts used regardless of equipment.

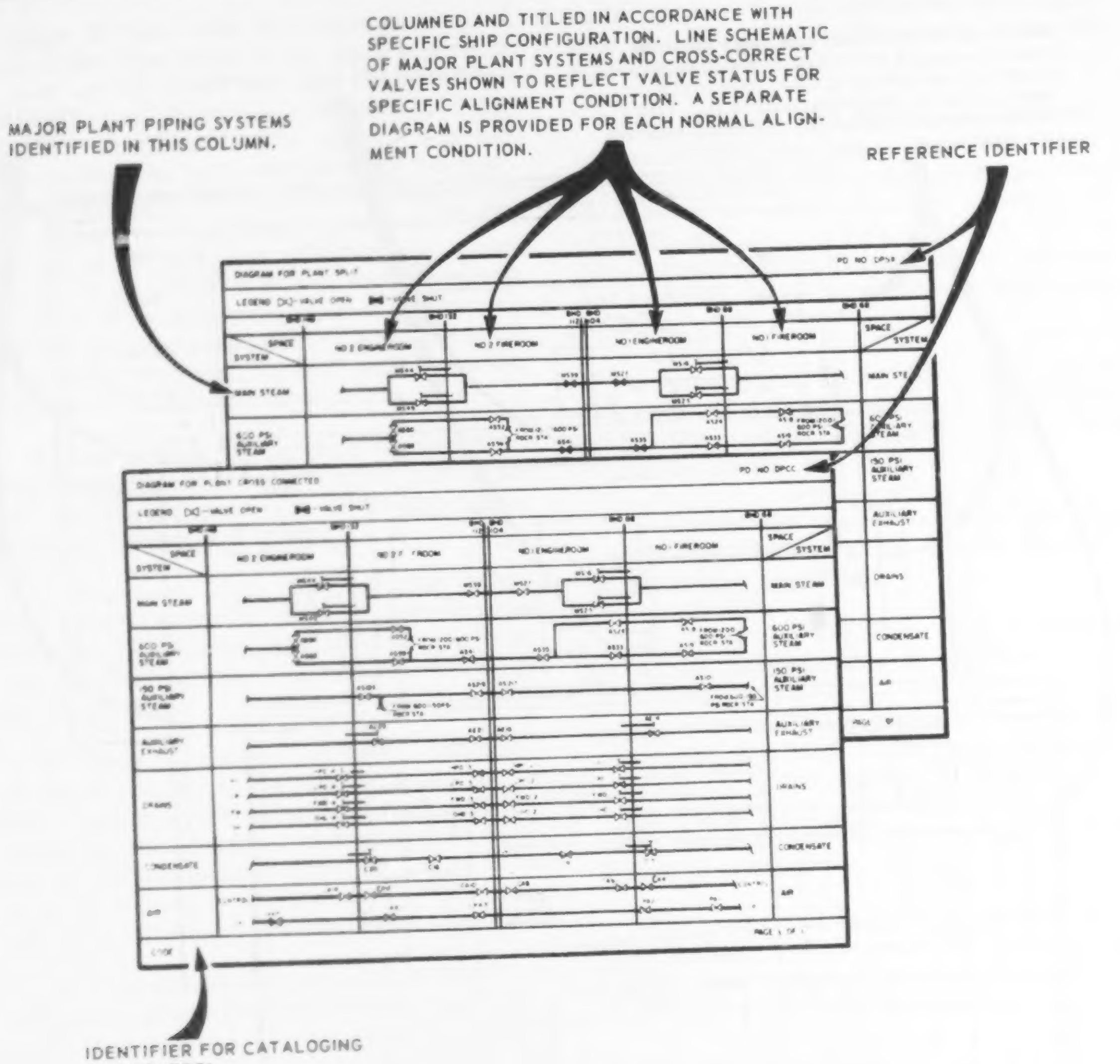

EOW USES GREASE PENCIL AND THIS LEGEND TO MAINTAIN CURRENT PLOT OF PLANT STATUS.
REFERENCE IDENTIFIER
PLANT STATUS DIAGRAM AT DATE/TIME
PD NO PSD
LEGEND: O-VALVE OPEN X-VALVE SHUT
BHD
BHD
BHD BHD
BHD
BHD
SPACE
SYSTEM
MAIN STEAM
600 PSI AUXILIARY STEAM
150 PSI
150 PSI AUXILIARY STEAM
AUXILIARY EXHAUST
DRAINS
CONDENSATE
AIR
PAGE OF
SIMPLIFIED SCHEMATIC OF MAJOR PLANT SYSTEMS SHOWING CROSS-CONNECT VALVES. VALVES ARE NUMBERED AS APPLICABLE TO A SPECIFIC SHIP.
PLANT STATUS DIAGRAM AT DATE/TIME
PD NO PSD
LEGEND: O-OPERATING S-SECURED △-STANDBY X-OUT OF COMMISSION
MACHINERY SPACES
EQUIPMENT
BOILERS
MAIN ENGINES
SHIP SERVICE GENERATORS
FORCED DRAFT BLOWERS
PAGE OF
LIST OF MAJOR EQUIPMENT ON SPECIFIC SHIP
THIS AREA COLUMNED AND TITLED IN ACCORDANCE WITH SPECIFIC SHIP CONFIGURATION. MACHINERY DESIGNATION IS ENTERED FOR EACH SPACE AS APPLICABLE.

121.27

Figure 3-2.—Sample plant status diagram.

- Plant status boards (fig. 3-2) providing a systematic display of the major systems and cross-connect valves as well as a graphic presentation of the major equipment in each machinery space. These boards are used to maintain a current plot of systems alignment and equipment operating status.

- A diagram for plant steaming conditions versus optimum generator combinations delineating the preferred electric power generator combinations for the various plant operating conditions. This diagram is also provided in the Stage II electrical documentation.


COLUMNED AND TITLED IN ACCORDANCE WITH SPECIFIC SHIP CONFIGURATION. LINE SCHEMATIC OF MAJOR PLANT SYSTEMS AND CROSS-CORRECT VALVES SHOWN TO REFLECT VALVE STATUS FOR SPECIFIC ALIGNMENT CONDITION. A SEPARATE DIAGRAM IS PROVIDED FOR EACH NORMAL ALIGNMENT CONDITION.
MAJOR PLANT PIPING SYSTEMS IDENTIFIED IN THIS COLUMN.
REFERENCE IDENTIFIER
SPACE
SYSTEM
NO 2 ENGINEROOM
NO 2 FIREROOM
NO 1 ENGINEROOM
NO 1 FIREROOM
MAIN STEAM
600 PSI AUXILIARY STEAM
150 PSI AUXILIARY STEAM
AUXILIARY EXHAUST
DRAINS
CONDENSATE
AIR
IDENTIFIER FOR CATALOGING AND CONTROL.

121.28

Figure 3-3.—Sample preferred alignment diagrams.

- System alignment diagrams (fig. 3-3) delineating the preferred initial and final alignment for each engineering plant.
- A diagram for equipment versus speed requirement delineating the equipment normally required for various ship speeds.
- A diagram for shore services connection locations delineating the location of shore service connections for steam, electrical power, feedwater, potable water, salt water, and fuel oil.
- Training diagrams (fig. 3-4) delineating each major piping system to aid in plant familiarization and training of newly assigned personnel. These diagrams indicate the relative locations of lines, valves, and equipment.

SIMPLIFIED PIPING DIAGRAMS ARE PROVIDED FOR EACH MAJOR SYSTEM IN THE PROPULSION PLANT OF THE SPECIFIC SHIP. THE DIAGRAMS PROVIDE READY REFERENCE MATERIAL FOR ALL OPERATORS AND SERVE AS A TRAINING AID FOR NEW PERSONNEL.

DIAGRAM TITLE NOTED HERE

REFERENCE IDENTIFIER

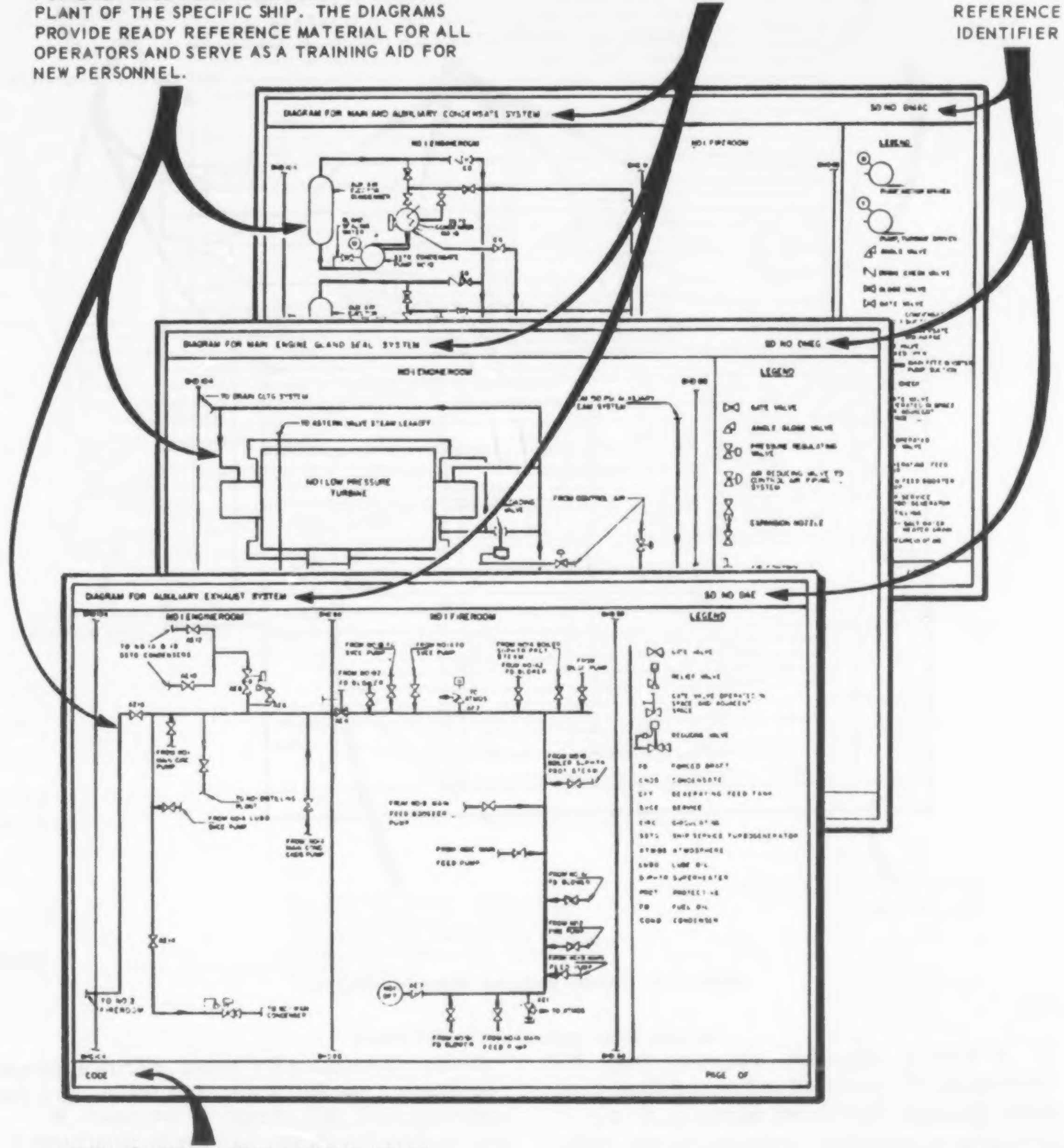


DIAGRAM FOR MAIN AND AUXILIARY CONDENSATE SYSTEM
NO 1 ENGINEROOM
NO 1 FIREROOM
LEGEND
DIAGRAM FOR MAIN ENGINE GLAND SEAL SYSTEM
NO 1 ENGINEROOM
LEGEND
NO 1 LOW PRESSURE TURBINE
DIAGRAM FOR AUXILIARY EXHAUST SYSTEM
NO 1 ENGINEROOM
NO 1 FIREROOM
LEGEND
CODE
PAGE OF

ALPHA/NUMERIC IDENTIFICATION CODES ARE NOTED ON EACH DIAGRAM TO FACILITATE CATALOGING AND CONTROL.

121.29

Figure 3-4.—Sample training diagram.

Stage II deals with the system component level under supervision of the space supervisor in each engine room and fireroom, and the electrical plant supervisor (electrical load dispatcher). In Stage II, the space supervisor accomplishes the tasks delegated by the plant supervisor. The EOP documentation assists the space supervisor in properly sequencing events, controlling the operation of equipment, maintaining an up-to-date status of the operational condition of the equipment assigned and training of newly assigned personnel. To assist the space supervisor in this effort, the EOP section provides the Stage II documents listed below.

- Index pages listing each document by identification number and title for each specified operating group such as engine room, fireroom, or electrical system.

- Space procedure charts (similar to the plant procedure chart) providing the step-by-step procedure to be accomplished within a space to satisfy and support the requirements of the plant procedure charts.

- Space status board providing a schematic of major systems and a tabular listing of the major equipment within the individual machinery spaces for maintaining a plot of system alignments and equipment operating status. This board is similar in configuration to that provided for the Stage I documentation (fig. 3-5).

- Diagram for electrical plant status (DLS) delineating generators, switchboards, and shore-power connections within the electrical distribution systems. The DLS is provided in both the electrical operating group and in the Stage I (EOOW) documentation for maintaining a plot of the system alignment.

- Diagram for plant steaming conditions versus optimum generator combinations provided in the electrical operating group documentation. This specifies the preferred electric power generator combination. This diagram is the same as that provided in the Stage I documentation.

- Training diagrams of each major piping system developed for Stage I, plus diagrams of such systems as fuel-oil service and main engine lube oil that are normally located within the machinery spaces.

Stage III deals with the system component level under the supervison of component operators. The component operators place equipment in and out of operation, align systems, and monitor and control their operation. This is done by manipulating required valves, switches, and controls. Stage III documents include the following:

- Index pages listing each document by identification number and title for each specified system such as fuel-oil service system, lube oil service system, and so forth.

- Component procedure cards providing step-by-step procedures for systems alignment or component operation.

- Component procedure cards as required to support each operation or alignment.

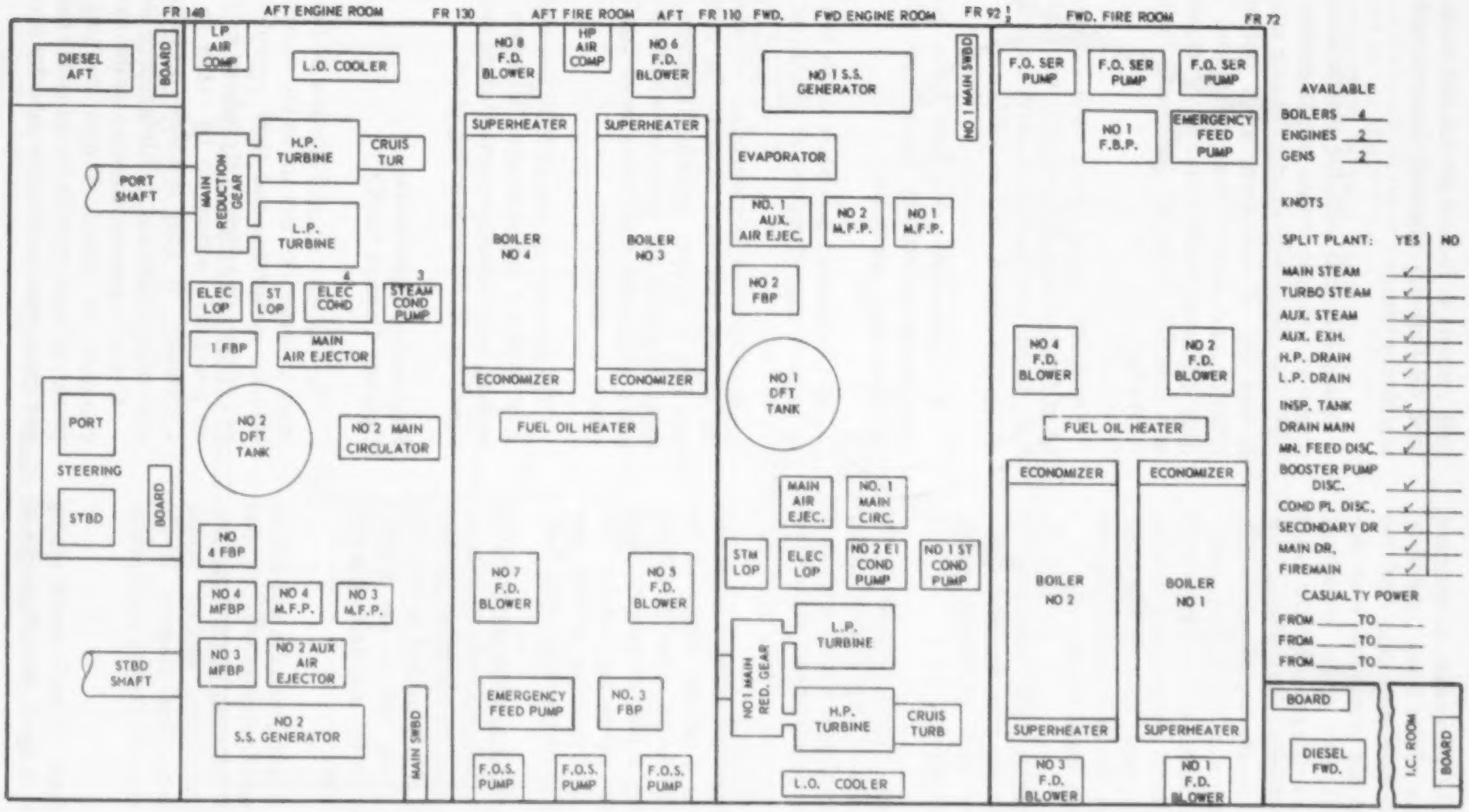
- Alignment diagrams (fig. 3-6) amplifying the written procedure to assist the component operator in proper systems alignment. Alignment diagrams are provided whenever two or more alignment conditions exist for a given system or component.

The operational use of EOP documentation is of primary importance at all levels in controlling, supervising, and operating the evolutional functions of the engineering plant.

Engineering Operational Casualty Control (EOCC)

The casualty control portion of EOSS contains information relevant to the recognition of casualty symptoms and their probable causes and effects. In addition, it contains information on preventive actions to be taken to prevent a casualty. It also specifies procedures for controlling single and multiple source casualties.

Casualty prevention must be the concern of everyone on board. Proper training of all personnel must provide for adequate knowledge and experience in effective casualty prevention.


FR 140
AFT ENGINE ROOM
FR 130
AFT FIRE ROOM
AFT
FR 110
FWD.
FWD ENGINE ROOM
FR 92 ½
FWD. FIRE ROOM
FR 72
DIESEL AFT
BOARD
PORT SHAFT
PORT
STEERING
STBD
BOARD
STBD SHAFT
LP AIR COMP
L.O. COOLER
MAIN REDUCTION GEAR
H.P. TURBINE
CRUIS TUR
L.P. TURBINE
ELEC LOP
ST LOP
4
ELEC COND
3
STEAM COND PUMP
1 FBP
MAIN AIR EJECTOR
NO 2 DFT TANK
NO 2 MAIN CIRCULATOR
NO 4 FBP
NO 4 MFBP
NO 4 M.F.P.
NO 3 M.F.P.
NO 3 MFBP
NO 2 AUX AIR EJECTOR
NO 2 S.S. GENERATOR
MAIN SWBD
NO 8 F.D. BLOWER
HP AIR COMP
NO 6 F.D. BLOWER
SUPERHEATER
BOILER NO 4
ECONOMIZER
SUPERHEATER
BOILER NO 3
ECONOMIZER
FUEL OIL HEATER
NO 7 F.D. BLOWER
NO 5 F.D. BLOWER
EMERGENCY FEED PUMP
NO. 3 FBP
F.O.S. PUMP
F.O.S. PUMP
F.O.S. PUMP
NO 1 S.S. GENERATOR
NO 1 MAIN SWBD
EVAPORATOR
NO. 1 AUX. AIR EJEC.
NO 2 M.F.P.
NO 1 M.F.P.
NO 2 FBP
NO 1 DFT TANK
MAIN AIR EJEC.
NO. 1 MAIN CIRC.
STM LOP
ELEC LOP
NO 2 E1 COND PUMP
NO 1 ST COND PUMP
NO 1 MAIN RED. GEAR
L.P. TURBINE
H.P. TURBINE
CRUIS TURB
L.O. COOLER
F.O. SER PUMP
F.O. SER PUMP
F.O. SER PUMP
NO 1 F.B.P.
EMERGENCY FEED PUMP
NO 4 F.D. BLOWER
NO 2 F.D. BLOWER
FUEL OIL HEATER
ECONOMIZER
BOILER NO 2
SUPERHEATER
ECONOMIZER
BOILER NO 1
SUPERHEATER
NO 3 F.D. BLOWER
NO 1 F.D. BLOWER
BOARD
DIESEL FWD.
I.C. ROOM
BOARD

AVAILABLE

BOILERS 4
ENGINES 2
GENS 2

KNOTS

SPLIT PLANT:	YES	NO
MAIN STEAM	✓	
TURBO STEAM	✓	
AUX. STEAM	✓	
AUX. EXH.	✓	
H.P. DRAIN	✓	
L.P. DRAIN	✓	
INSP. TANK	✓	
DRAIN MAIN	✓	
MN. FEED DISC.	✓	
BOOSTER PUMP DISC.	✓	
COND PL. DISC.	✓	
SECONDARY DR	✓	
MAIN DR.	✓	
FIREMAIN	✓	

CASUALTY POWER

FROM ____ TO ____
FROM ____ TO ____
FROM ____ TO ____

111.59

Figure 3-5.—Casualty control board.

DESCRIPTION OF SPECIFIC DIAGRAM. OPERATIONAL DIAGRAM IS PROVIDED WHEN NECESSARY TO CLARIFY OPERATIONAL PROCEDURE SET FORTH IN A COMPONENT/ SYSTEM PROCEDURE CARD.

REFERENCE IDENTIFIER

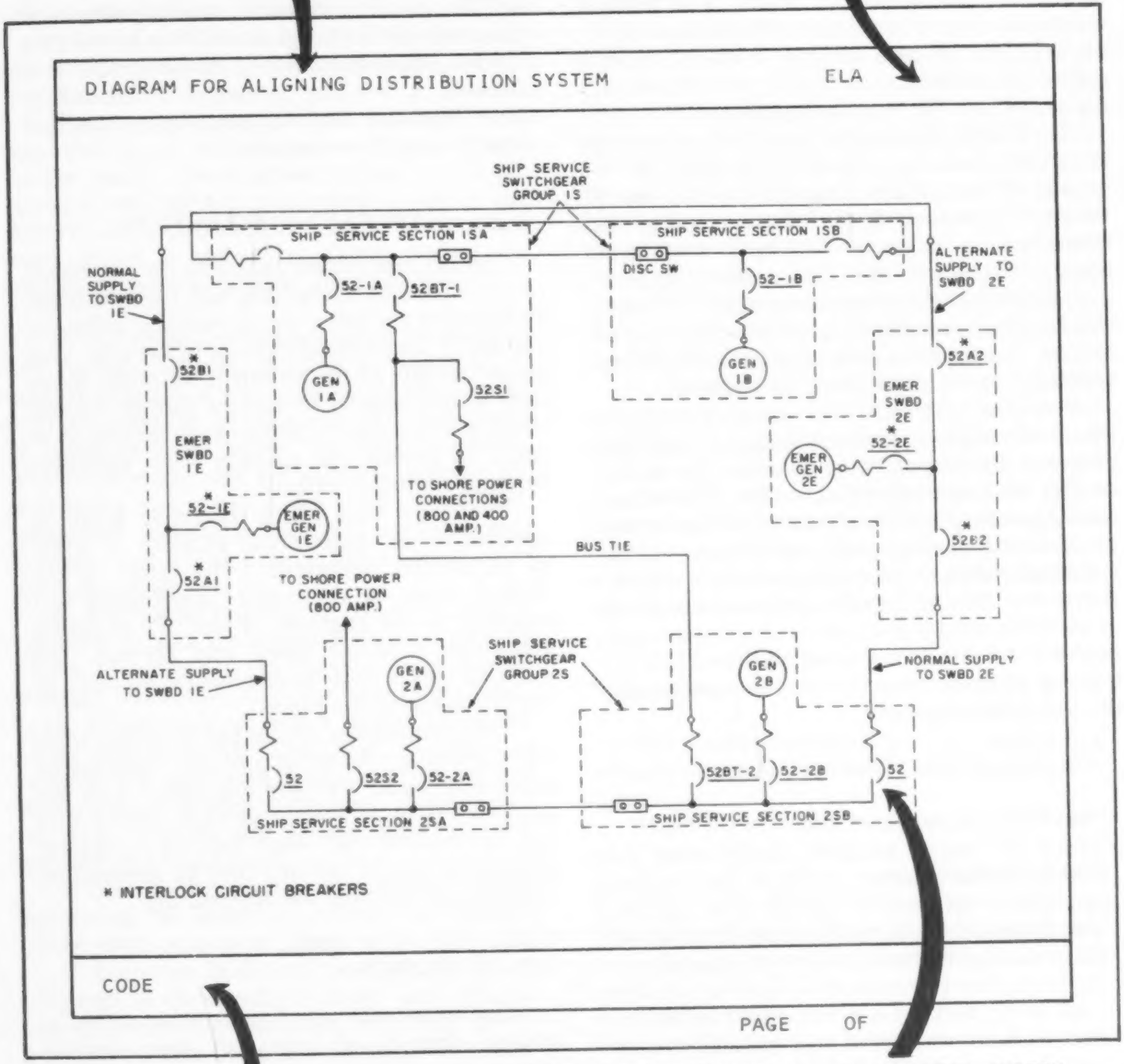


DIAGRAM FOR ALIGNING DISTRIBUTION SYSTEM
ELA
SHIP SERVICE SWITCHGEAR GROUP 1S
SHIP SERVICE SECTION 1SA
SHIP SERVICE SECTION 1SB
DISC SW
NORMAL SUPPLY TO SWBD 1E
ALTERNATE SUPPLY TO SWBD 2E
52-1A
52BT-1
52-1B
GEN 1A
GEN 1B
52S1
52B1
52A2
EMER SWBD 1E
EMER SWBD 2E
52-2E
EMER GEN 2E
TO SHORE POWER CONNECTIONS (800 AND 400 AMP.)
52-1E
EMER GEN 1E
BUS TIE
52A1
52B2
TO SHORE POWER CONNECTION (800 AMP.)
SHIP SERVICE SWITCHGEAR GROUP 2S
GEN 2A
GEN 2B
ALTERNATE SUPPLY TO SWBD 1E
NORMAL SUPPLY TO SWBD 2E
52
52S2
52-2A
52BT-2
52-2B
52
SHIP SERVICE SECTION 2SA
SHIP SERVICE SECTION 2SB
* INTERLOCK CIRCUIT BREAKERS
CODE
PAGE OF

IDENTIFIER FOR CATALOGING AND DOCUMENT CONTROL.

SIMPLIFIED SCHEMATIC OF SPECIFIC SYSTEM UNDER CONSIDERATION. COMPONENT IS NUMBERED TO FACILITATE SYSTEM ALIGNMENT BY OPERATOR AS HE REFERES TO THE RELATED PROCEDURE CARD.

77.252

Figure 3-6.—Sample component/system alignment diagram.

The EOCC manual contains efficient, technically correct casualty control and prevention procedures. These procedures relate to all phases of an engineering plant. The EOCC documents possible casualties that may be caused by human error, material failure, or battle. The EOCC manual describes proven methods for the control of a casualty. It also provides information for prevention of further damage to the component, the system, or the engineering plant.

The EOCC manuals are available to personnel in their own machinery space so that they can be used as a means of self-indoctrination for newly assigned personnel. It can also be used as an instrument to improve casualty control procedure techniques for all watch standers. The manual contains documentation to assist engineering personnel in developing and maintaining maximum proficiency in controlling casualties to the ship's propulsion plant.

Proficiency in EOCC procedures is maintained through a well-administered training program. Primary training concentrates on the control of single source casualties. These are casualties which may be attributed to the failure or malfunction of a single component or the failure of piping at a specific point in a system. Advanced training concentrates on the control of multiple casualties or on conducting a battle problem. An effective, well-administered EOOW training program must contain, as a minimum, the following elements:

- Recognition of the symptoms
- Probable causes
- Probable effects
- Preventive actions that may be taken to reduce, eliminate, or control casualties

An EOSS package is not intended to be forgotten once it is developed and installed aboard a ship. It offers many advantages to the ship's operational readiness capabilities and provides detailed step-by-step sequencing of events for all phases of the engineering plant operation. Because it is work studied and system oriented, the EOSS provides the basic information for the optimum utilization of equipment and systems. It does this by specifying correct procedures tailored for a specific plant configuration.

The EOSS is not intended to eliminate the need for skilled plant operators. No program or system can achieve such a goal. The EOSS is a tool for better utilization of manpower and skills available. Although the EOSS is an excellent tool for shipboard training of personnel, it is primarily a working system for scheduling, controlling, and directing plant operations and casualty-control procedures.

CASUALTY CORRECTION

Casualty correction deals with the correction of the effects of operational and battle damage to minimize the effect on the mobility, offensive capability, and defensive power of the ship. This phase consists of the actions to be taken at the time of the casualty to prevent further damage to the affected unit. It also includes actions to be taken to prevent the casualty from spreading through secondary effects.

The speed with which corrective action is applied to an engineering casualty is often of paramount importance. The extent of the damage must be thoroughly investigated and reported to the engineer officer. To maintain maximum available speed and services, the engineer officer must be informed at all times of the condition of the plant.

The commanding officer has the responsibility of deciding whether to continue operation of equipment under casualty conditions with the possible risk of permanent damage. Such action can be justified only when the risk of greater damage or loss of the ship may be incurred by immediately securing the affected unit.

CASUALTY CONTROL ORGANIZATION

The speed with which corrective action is applied depends on how well your casualty control organization is set up. It also depends upon the amount of training that has been conducted.

Engineering Officer of the Watch

The EOOW is the officer on watch in charge of the main propulsion plant and associated auxiliaries. On most types of ships, the EOOW is normally a senior petty officer. As an EM1 or EMC, you will be primarily responsible for the safe and efficient performance of the engineering department watches (except damage control). The engineer officer determines who is qualified to perform the duties of the EOOW, and makes his recommendation to the commanding officer for final qualification.

When the engineer officer considers you qualified in all respects, you will be assigned to the watch. The engineer officer or, in his absence, the MPA is authorized to direct the EOOW concerning the duties of the watch when such action is necessary. Other duties you should perform as EOOW are listed below.

1. Make frequent inspections of the machinery (boilers, engines, generators, evaporators, and auxiliaries) in the engineering department for the purpose of ensuring that machinery is being operated under current instructions. Ensure required logs are properly maintained, machinery and controls are properly manned, applicable inspections and tests are being performed, and all applicable safety precautions are being observed.
2. Frequently monitor IC circuits to ensure required circuits are properly manned. Ensure circuit discipline is maintained and correct message procedures and terminology are used.
3. Ensure that all orders received from the OOD concerning the speed and direction of rotation of the main propulsion shafts are promptly and properly executed. Also, ensure the engineering log and the engineer's bell book are properly maintained.
4. Immediately execute all emergency orders concerning the speed and direction of rotation of the main propulsion shafts.
5. Keep the OOD and the engineer officer informed of the condition of the main propulsion plant and the maximum speed and power available with the boiler and machinery combinations that are in use.
6. Ensure that all directives and procedures issued by higher authority are observed.
7. Know the power requirements for all possible operations. Determine that the boiler and machinery combinations in use effectively meet current operational requirements. Advise the engineer officer and the OOD when modification of the machinery combinations in use is considered appropriate. Inform the OOD of any necessary changes in the operation of boilers, main engines, generators, and other major auxiliaries.
8. Supervise the training of the personnel on watch. To ensure effective training is held, it is necessary for the EOOW to understand specific operation and maintenance of engineering plant equipment. Refer to *Machinist Mate 3 & 2*, NAVEDTRA 10535-H, chapters 2, 3, 4, 9, and 10 and *Boiler Technician 3 & 2*, NAVEDTRA 10535-H, chapters 2, 3, 4, 7, 8, 9, and 10 for this information. The EOOW should insist that each person in charge of an engineering watch station carefully instruct the personnel under their charge in specific duties and in the duties of all persons on the same watch station.
9. Perform such other duties as the engineer officer may direct. The EOOW reports to the OOD for changes in speed and direction of rotation of the main propulsion shafts and for requirements of standby power and other engineering services anticipated or ordered. The EOOW reports to the engineer officer for technical control and matters affecting the administration of the watch.

Watch Teams

The basic organization for engineering casualty control is the watch team in each main space.

Watch teams should be thoroughly organized with each person assigned duties for watch standing and casualty control duties for fire, flooding, and setting of material conditions. The petty officer in charge of each team should maintain complete control to avoid confusion which could disrupt organization and coordination of the team.

Dissemination of information to all stations is extremely important in effectively controlling engineering casualties. The engineer officer must receive brief, clear, and concise information from all stations. This is needed to properly administer the operation of the engineering plant and to promptly order corrective measures for the control of casualties.

The sound-powered telephone (circuit 2JV) is the principal means of transmitting engineering casualty information. The telephone talker has an important job, and this individual is the key to good communications. If a message is not relayed promptly and correctly, it may place the ship in danger. In battle, the safety of the ship and the crew depends on how well the talker uses his voice and equipment. The importance of officers and petty officers being proficient in using proper engineering terms and phraseology cannot be overstressed. It is not the responsibility of the talker to decipher, translate, or rephrase improperly transmitted orders. This is the responsibility of the person issuing the order or originating the message. It is the duty of the talker to relay messages as given.

Standard wording greatly enhances communications within and between teams. It minimizes confusion by reducing the amount of conversation so that transmissions are easily relayed and understood. When it is practical, one command should initiate an entire casualty procedure. It is much more effective within the team and between teams to pass the command, "cross-connect the plant," or "cross-connect main feed, port side," than "open valves main steam 15, main steam 8, auxiliary steam 79 and 80, and auxiliary 44."

If the command from main engine control is "cross-connect main feed, starboard side," the petty officers in charge of No. 1 and No. 2 firerooms will repeat "cross-connect main feed, starboard side." The men already assigned this procedure will open the correct valves with no further command. The men should report back when a job is done. This is because the engineer officer often has to wait for a report before giving another command. The use of good talker procedure and standard wording will show immediate results.

Casualty Control Board

The casualty control board (fig. 3-5) is essential to effective casualty control during battle conditions. It furnishes a complete picture of the machinery available to the engineer officer at general quarters and watch personnel during normal watches.

For optimum results, a casualty control board should be installed at the main engine control, the after engine room, and at the main propulsion repair party station. The 2JV talkers at these stations should be responsible for maintaining the boards. The status of machinery is indicated by marking the affected unit with a grease pencil on the Plexiglass front of the casualty control board.

The casualty control board in figure 3-5 is an example and is not suitable for all ship types.

Repair Party

In NAVPERS 18068-D (*Manual of Navy Enlisted Manpower and Personnel and Occupational Standards*), one of the requirements for an EM1 or EMC is to supervise a damage control repair party. Being the leader, you must be familiar with all the equipment used and the function of each. You must train your personnel in the use of the equipment and the functions of the repair party. A list of functions which are common to all repair parties is listed below.

1. Each party must be capable of making repairs to electrical and sound-powered telephone circuits.
2. Each party must be capable of giving first aid and transporting injured personnel to battle dressing stations without seriously reducing the damage control capabilities of the repair party.
3. Each party must be capable of detecting, identifying, and measuring dose and dose-rate intensities from radiological contamination. They must be able to survey and decontaminate contaminated personnel and areas, except where specifically assigned to another department as in the case of nuclear weapons accident/incident.
4. Each party must be capable of sampling and/or identifying biological or chemical agents. They must be able to decontaminate areas and personnel affected as a result of biological or chemical attack, except where this responsibility is assigned to the medical department.
5. Each party must be capable of controlling and extinguishing all types of fires.
6. Each party must be organized to evaluate and correctly report the extent of damage in

its area. This will include maintaining the following:

a. Deck plans showing locations and safe routes to NBC decontamination, battle dressing, and personnel cleaning stations.

b. A casualty board for visual display of structural damage.

c. A graphic display board showing damage and action taken to correct disrupted or damaged systems. The use of standard damage control symbology and the accompanying preprinted message format are recommended to facilitate the recording and transmittal of damage control information. Use standard damage control symbology, as shown in figures 3-7, 3-8, 3-9, to write and read message formats such as shown in figure 3-10. In reading this message, you should have come up with the following information: An 8-inch hole, 4 feet up from the deck at frame 38, starboard side of compartment 2-35-0-L.

Some of the specific functions for which Repair 5 is responsible in its own assigned area are listed below.

1. Maintenance of stability and buoyancy. Members of the repair party must meet the following criteria:

a. Be stationed so that they can reach all parts of their assigned area with a minimum opening of watertight closures.

b. Be able to repair damage to structures, closures, or fittings that are designed to maintain watertight integrity, by shoring, plugging, welding, or caulking bulkheads and decks, resetting valves, and blanking or plugging lines through watertight subdivisions of the ship.

c. Be prepared to sound, drain, pump, counterflood, or shift liquids in tanks, voids, or other compartments; and be thoroughly familiar with the location and use of all equipment and methods of action.

d. Maintain two status boards for accurate evaluation of underwater damage: The Stability Status Board (Flooding Effects Diagram) is to be used for visual display of all flooding, flooding boundaries, corrective measures taken, and effects on list and trim; and the Liquid Load Status Board is to show the current status of all fuel and water tanks and the soundings of each tank in feet and inches.

2. Maintenance of ship's propulsion. The personnel in the repair party must be able to do the following:

a. Maintain, repair, or isolate damage to main propulsion machinery and boilers.

b. Operate, repair, isolate, modify or segregate vital systems.

c. Assist in the operation and repair of the steering control systems.

d. Assist in the maintenance and repair of communications systems.

e. Assist Repairs 1, 2, 3, and 4 and the crash and salvage team when required.

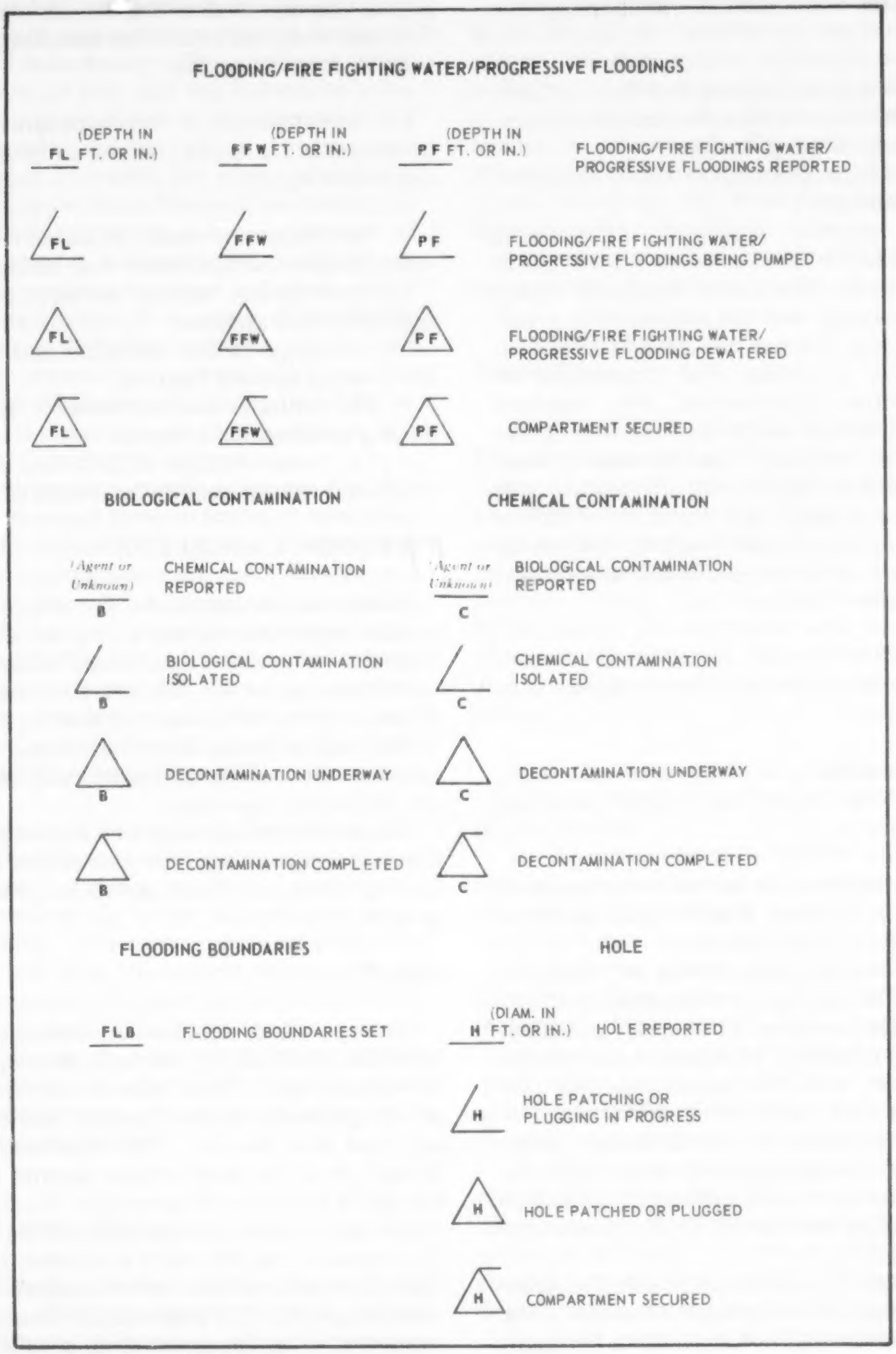
FIREROOM CASUALTIES

Under all circumstances, the fireroom watch section supervisor should notify the EOOW of fireroom casualties. Engine room action is based on reports given by the fireroom supervisor. When a fireroom casualty affects the operation of the engine room, cooperation and communication between personnel of both the spaces are extremely important.

Some of the fireroom casualties that affect the engine room and the procedures for controlling them, are listed in the following paragraphs.

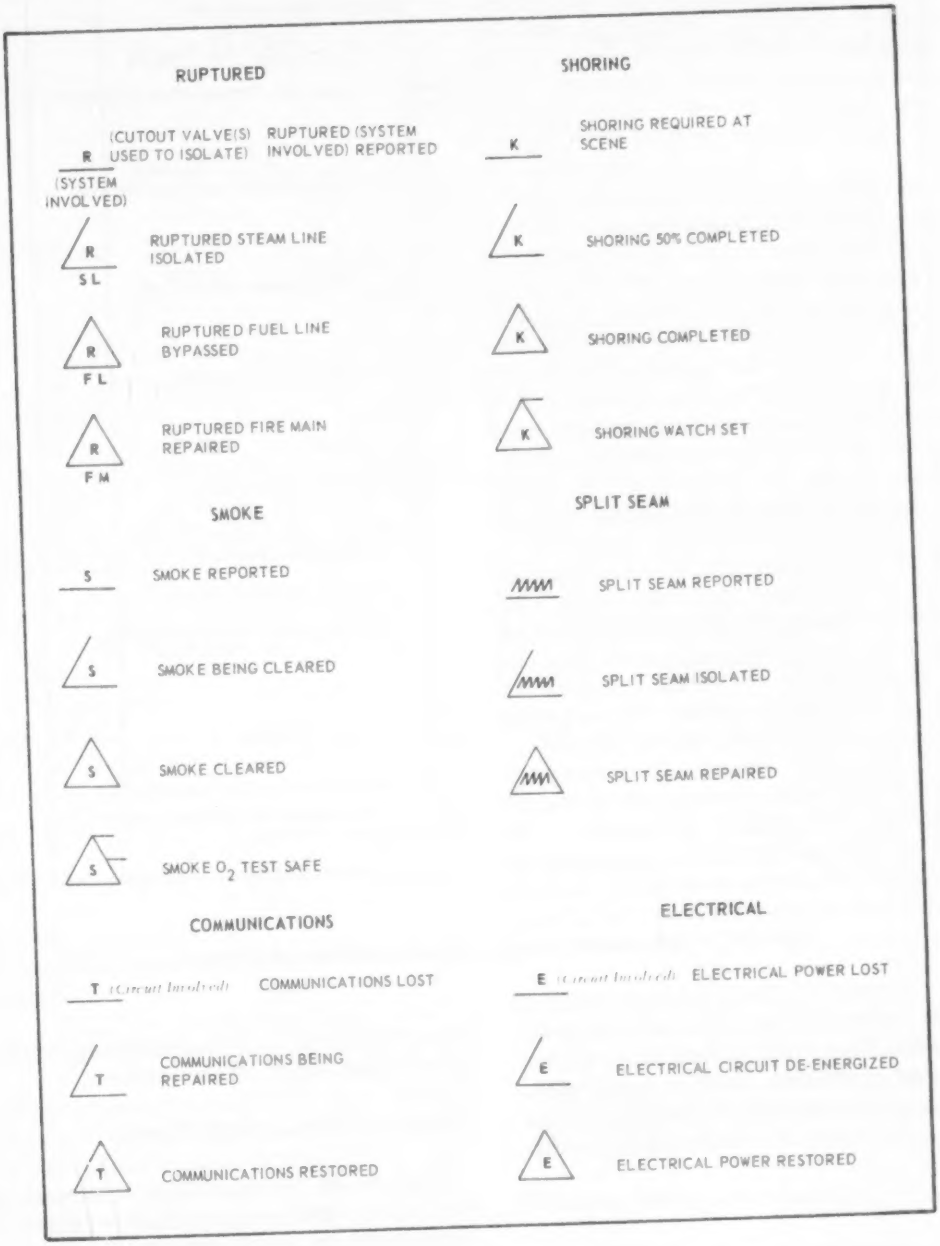
High Water

In the event of the fireroom casualty, HIGH WATER IN BOILER, with split plant operation, the Electrician's Mate should trip the ship's service generator circuit breaker and close the a.c. and d.c. bus-ties. The Machinist's Mate should close the main engine throttle and trip the ship's service turbogenerator. All steam line drains and all turbine drains should be opened. This ensures that all water is drained from the steam lines and turbines before the cross-connect valve is opened. The plant should then be cross-connected to receive steam from another boiler. These procedures should be carried out simultaneously. The fireroom watch should close the feed check valve, secure the burners, stop the


FLOODING/FIRE FIGHTING WATER/PROGRESSIVE FLOODINGS
FL (DEPTH IN FT. OR IN.)
FFW (DEPTH IN FT. OR IN.)
PF (DEPTH IN FT. OR IN.)
FLOODING/FIRE FIGHTING WATER/ PROGRESSIVE FLOODINGS REPORTED
FL
FFW
PF
FLOODING/FIRE FIGHTING WATER/ PROGRESSIVE FLOODINGS BEING PUMPED
FL
FFW
PF
FLOODING/FIRE FIGHTING WATER/ PROGRESSIVE FLOODING DEWATERED
FL
FFW
PF
COMPARTMENT SECURED
BIOLOGICAL CONTAMINATION
(Agent or Unknown)
B
CHEMICAL CONTAMINATION REPORTED
B
BIOLOGICAL CONTAMINATION ISOLATED
B
DECONTAMINATION UNDERWAY
B
DECONTAMINATION COMPLETED
CHEMICAL CONTAMINATION
(Agent or Unknown)
C
BIOLOGICAL CONTAMINATION REPORTED
C
CHEMICAL CONTAMINATION ISOLATED
C
DECONTAMINATION UNDERWAY
C
DECONTAMINATION COMPLETED
FLOODING BOUNDARIES
FLB
FLOODING BOUNDARIES SET
HOLE
H (DIAM. IN FT. OR IN.)
HOLE REPORTED
H
HOLE PATCHING OR PLUGGING IN PROGRESS
H
HOLE PATCHED OR PLUGGED
H
COMPARTMENT SECURED

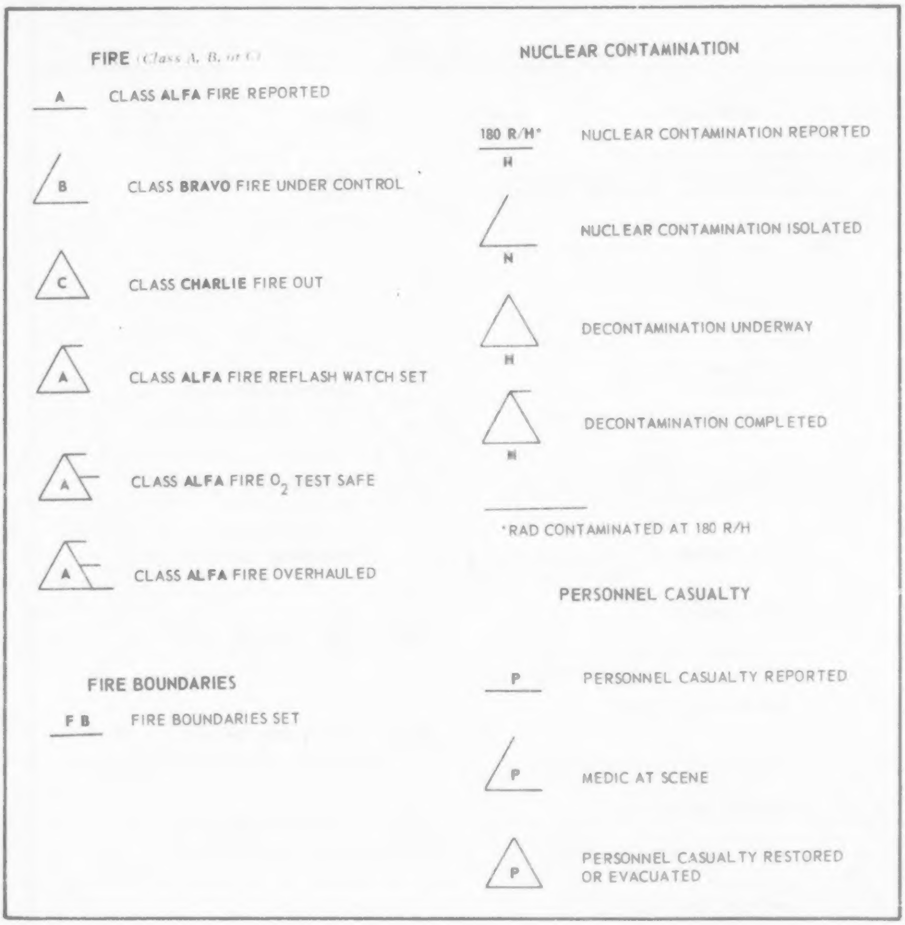
8.83(188)BC

Figure 3-7.—Navy standard damage control symbology.


RUPTURED
R
(CUTOUT VALVE(S) USED TO ISOLATE)
(SYSTEM INVOLVED)
RUPTURED (SYSTEM INVOLVED) REPORTED
R
SL
RUPTURED STEAM LINE ISOLATED
R
FL
RUPTURED FUEL LINE BYPASSED
R
FM
RUPTURED FIRE MAIN REPAIRED
SMOKE
S
SMOKE REPORTED
S
SMOKE BEING CLEARED
S
SMOKE CLEARED
S
SMOKE O2 TEST SAFE
COMMUNICATIONS
T (Circuit Involved)
COMMUNICATIONS LOST
T
COMMUNICATIONS BEING REPAIRED
T
COMMUNICATIONS RESTORED
SHORING
K
SHORING REQUIRED AT SCENE
K
SHORING 50% COMPLETED
K
SHORING COMPLETED
K
SHORING WATCH SET
SPLIT SEAM
SPLIT SEAM REPORTED
SPLIT SEAM ISOLATED
SPLIT SEAM REPAIRED
ELECTRICAL
E (Circuit Involved)
ELECTRICAL POWER LOST
E
ELECTRICAL CIRCUIT DE-ENERGIZED
E
ELECTRICAL POWER RESTORED

8.83(188)TE

Figure 3-8.—Navy standard damage control symbology—Continued.


FIRE (Class A, B, or C)
A
CLASS ALFA FIRE REPORTED
B
CLASS BRAVO FIRE UNDER CONTROL
C
CLASS CHARLIE FIRE OUT
A
CLASS ALFA FIRE REFLASH WATCH SET
A
CLASS ALFA FIRE O_2 TEST SAFE
A
CLASS ALFA FIRE OVERHAULED
FIRE BOUNDARIES
F B
FIRE BOUNDARIES SET
NUCLEAR CONTAMINATION
180 R/H*
H
NUCLEAR CONTAMINATION REPORTED
N
NUCLEAR CONTAMINATION ISOLATED
H
DECONTAMINATION UNDERWAY
H
DECONTAMINATION COMPLETED
*RAD CONTAMINATED AT 180 R/H
PERSONNEL CASUALTY
P
PERSONNEL CASUALTY REPORTED
P
MEDIC AT SCENE
P
PERSONNEL CASUALTY RESTORED OR EVACUATED

8.83(188)ABC

Figure 3-9.—Navy standard damage control symbology—Continued.

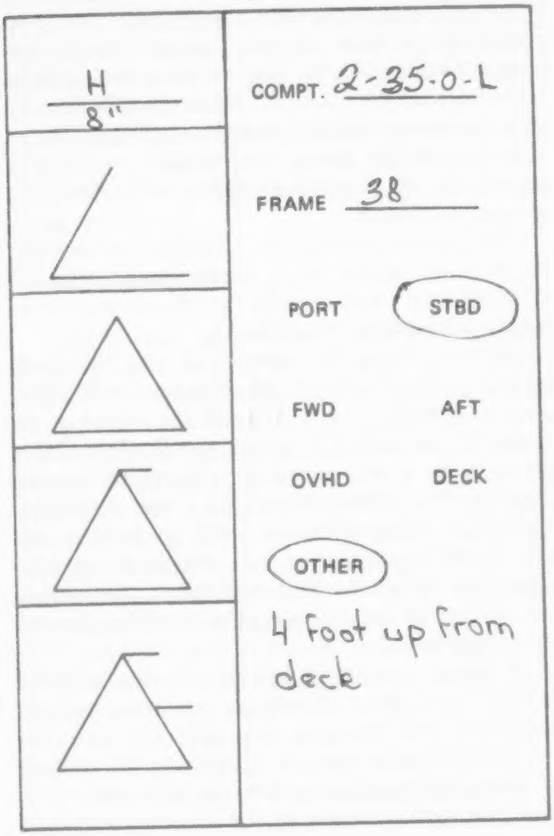
blowers, and close the main, the turbogenerator, and the auxiliary boiler steam stop valves. After the boiler is secured, the fireroom watch should run down the water to the steaming level, relight fires, and bring the boiler back on the line.

Low Water

The fireroom casualty, LOW WATER IN BOILER, also requires that the affected boiler be secured. It is not necessary to trip the ship's service generator as in the case of high water. However, speed in cross-connecting is important to maintain steam to the turbines.

Failure of Forced Draft Blower

Failure of a forced draft blower can be serious, depending on existing conditions. If two blowers are in use and the speed of the ship is high, the ship will have to be slowed. If only one blower is in use, its failure will necessitate securing of the boiler until another blower can be started. If there is only one boiler furnishing steam to a space, the Machinist's Mate should



H

8"

COMPT. 2-35-0-L

FRAME 38

PORT [✓ STBD]

FWD AFT

OVHD DECK

[✓ OTHER]

4 foot up from deck

188.27.1

Figure 3-10.—Preprinted message format.

cross-connect the space and take steam from another boiler.

Loss of Fuel Oil Suction

The loss of fuel oil suction will cause boiler burners to sputter, fires to die out, and possible racing of the fuel-oil service pump.

The fireroom watch secures all burners, leaving at least one air register on each side (superheated and saturated) open to expel any gases and to supply air for combustion of any oil that may have accumulated on the boiler floors. The forced draft blowers are kept running to purge the furnace (use purge chart applicable to ship's boilers).

The standby pump should be started with suction on the standby service tank. The watch notifies the engine room of the casualty and that the fires are secured. If unable to regain fires before steam pressure drops to a predetermined value, the watch notifies the engine room that the boiler is being secured. The main, turbo, and auxiliary boiler steam stops are then closed in the order listed.

The fireroom watch should notify the EOOW that the boiler is secured. The watch should then open the cross-connect valves when so directed. The service pump discharge pressure should be observed. If the pump races and the noise level increases, there is water in the oil. If no pressure is indicated, the pump is air bound. If there is water in the oil, the watch should run the oil to the contaminated oil tank through the recirculating line until the service line is free of water. If the pump is air bound, the priming cock should be opened and the system vented.

Fireroom personnel should close the air registers and slow down the forced draft blower after all oil has been burned from the furnace deck and all combustible gases expelled. After it has been determined that good oil is available, the Boiler Technicians should carry out the procedure for placing a boiler on the line.

The BTs should then investigate and correct the cause of the trouble and sound the tank to determine the quantity of oil in the tank. If the oil is above the suction line, the fuel oil is contaminated or the suction line is clogged. If the fuel oil contains water, the tanks should be sounded or tests performed to find the source of the contamination.

ENGINE ROOM CASUALTIES

The operational engine room casualties that might occur include excessive vibration of a shaft, vibration of a turbine, loss of lube oil, and many others.

Excessive Vibration of Shaft

If a shaft develops excessive vibration, watch personnel should obtain permission to slow the engine until the vibration ceases. The other engine should be speeded up to maintain speed if the tactical situation requires. If vibration continues at all speeds, permission should be obtained to stop and lock the shaft to investigate the shaft bearings. If the cause is undetermined, the propeller, fairwaters (sleeves), and rope guards should be investigated at the first opportunity.

Vibration of Turbine

If a turbine begins to vibrate, the individuals on watch should, with permission, slow down the engine and reduce the superheat temperature. A rumbling noise probably indicates the presence of water in the casing. This could be either from boiler priming or inadequate casing drainage.

If the turbine has been standing idle for more than 5 minutes without being spun, it is probable that the rotor has been bowed temporarily. Upon restarting the turbine, vibration may be evident. If so, a brief slowing of the turbine will usually permit the rotor to straighten.

Loss of Lube Oil

All personnel should know that even a momentary loss of lubricating oil can result in localized overheating and probable slight wiping of one or more bearings. Such wiping may result in only a momentary rise in the temperature of the lubricating oil discharged from the bearing(s). Damage can be prevented or minimized by stopping the shaft rotation and quickly restoring the lubricating oil flow. Continued operation with wiped bearings can cause serious derangement to the shaft packing, oil seals, and blading.

Loss of lubricating oil pressure may be caused by failure of the system itself. This includes failure of the main lubricating oil pumps, failure of steam or electrical power supply to the main lubricating oil pumps, or damage to boilers, steam lines, or electrical equipment.

Failure of component parts of the lube oil system may be caused by the presence of dirt, rags, or other foreign matter. This is usually the result of improper cleaning. Failure of the system may be caused by a piping failure, by a failure of the operating pump, or by failure of the standby pump to start. Standby pumps should be maintained ready to start the moment the pressure drops below a prescribed operating value. If automatic starting devices are not available on steam-driven pumps, the pumps should be lined up so that opening the throttle is the only action required. Steam supply lines to standby pumps should be drained continuously. Where electrical pumps are installed, personnel should be thoroughly familiar with alternate sources of power.

The general procedure when low lubricating oil pressure occurs is to immediately stop the affected shaft and simultaneously endeavor to regain lubricating oil pressure.

If steam pressure is available, stop the shaft by using the astern throttle. Engage the jacking gear and apply the brake. If the speed is in excess of one-half full power speed, slow down the ship to a safe speed by closing the ahead throttle, open the astern throttle and then lock the shaft. Listen for, and try to locate, the source of any unusual or abnormal sounds. After the affected shaft is secured, the ship's speed may be increased to the limit for locked shaft operation.

If steam pressure is lost in one engine room during split plant operation and the tactical situation permits, take way off the ship by backing the other engine. Determine the nature of the casualty causing the loss of steam. If a loss of steam pressure in the engine room will not cause a loss of steam to the other plant, open the auxiliary and the main steam cross-connections immediately. If the damage caused a loss of steam to the other plant, isolate the damage and then open the auxiliary and the main steam cross-connections as soon as possible. Stop and lock the affected shaft as soon as steam is available.

ELECTRIC PLANT CASUALTIES

Knowing the maximum operating limits of the electric plant is of prime importance during casualty operation. You must know the maximum allowable bearing temperatures, generator winding temperatures, maximum generator loads, and so forth.

Supplying vital power during casualty operation may require that generators be operated under overload conditions. Assuming that the prime mover can handle the overload, the temperature of the generator windings is the determining factor during sustained overloads. A portable blower may be used on open type machines to keep the winding temperature within safe limits.

Operational electric plant casualties that might occur include loss of generator, electrical fires, loss of lube oil, and overloaded generator.

Electrical Fires

The proper procedure in the event of an electrical fire is for the assigned Electrician's Mate to de-energize the power supply (normal alternate and emergency) to the affected controller, power panel, or switchboard. The EM should then report the fire to the engineering officer of the watch or the officer of the deck. The individual should then use a CO_2 fire extinguisher on the fire and secure all ventilation. He should not stand directly in front of the panel that is on fire. He should keep low and to one side and set a reflash watch until the danger of a reflash has passed. The electrician should open the panel with rubber gloves, using a rubber mat or boots as additional insulation, to determine the source of trouble and effect repairs.

If an electrical fire should occur in a switchboard with a generator on the line, the appropriate circuit breakers should be tripped (fig. 3-5). The Machinist's Mate should actuate the overspeed trip on the generator and notify the EOOW who, in turn, notifies the officer of the deck and the engineer officer.

The Electrician's Mate should secure the voltage regulator, trip the bus-tie circuit breaker, and open the feedback circuit breaker. If the fire is in the forward switchboard, he should notify the after switchboard watch to open the after bus-tie circuit breaker and should then use a CO_2 fire extinguisher on the fire. The damaged section of the switchboard should not be reenergized until repairs have been made.

If an electrical fire occurs in a generator, the generator should be secured immediately. If the fire occurs while operating split plant, the Electrician's Mate should trip the generator circuit breaker for the affected generator and close the bus-tie. Use a CO_2 fire extinguisher on the fire. If a generator fire should occur during operation with a single generator, the switchboard should be stripped of all nonvital circuits after opening the generator breaker. The vital circuits should then be supplied from the emergency diesel generator.

Loss of Lube Oil

Upon failure of generator lube oil pressure, the electrical load should be removed from the affected generator. The generator should be stopped immediately. The normal procedure is to trip the generator circuit breaker, close the bus-tie, and close the generator turbine throttle valve. The hand-operated lube oil pump should be used to maintain lube oil pressure to the bearings until the turbine is completely stopped. After the turbine has stopped, investigate and correct the casualty.

Overloaded Generator

Overload on a generator is reduced by removing nonvital loads. Power should not be interrupted to vital machinery and circuits unless absolutely necessary. Vital machinery and circuits include the steering gear, IC switchboard, fire pumps, drainage pumps, vital auxiliaries in the fire and engine rooms, gun mounts, and navigational lights.

DIESEL ELECTRIC D.C. DRIVE (FLEET TUG) CASUALTIES

Operational casualties that may occur to this type of drive include casualties to any one of the four main propulsion generators or exciters. It can also occur to the main propulsion motors, control equipment, and associated circuits.

Propulsion Generator Casualty

A casualty to one of the main propulsion generators or exciters requires cutting the affected generator out of the series propulsion loop. It is not necessary to turn the speed controller to the STOP position when cutting the generator into or out of the propulsion circuit. Normally, the controller should be brought to a position not higher than the 11th (engine operating at 350 rpm). When it is required, a generator may be cut out of the circuit while the engine speed is in excess of 350 rpm. The generator setup switches are designed for such service. Wait several seconds between the opening of the generator's control switch and its setup switch. This reduces arcing at the setup switch contacts. It also prevents flashover of the generator commutator.

Control Console Casualty

A casualty to the pilothouse control console or associated circuitry requires a shift in control of the engines to the engine room station. To shift control to the engine room, place the controllers at both control stations in the STOP position. Turn the excitation control switch to OFF. Then turn the engine room-pilothouse control transfer switch to the ENGINE ROOM position. The control transfer switch and the excitation control switch are interlocked so that the excitation control switch has to be in the OFF position before the control transfer switch can be operated. Then turn the excitation control switch in the engine room to ON.

BATTLE CASUALTIES

Shell or torpedo hits in engineering spaces usually result in multiple casualties to machinery systems and personnel. The corrective action for any particular casualty depends on the location and extent of damage. While battle casualties differ in many respects, the following procedures can be applied to most casualties of this type.

Secure the space or isolate damaged sections as practical. Cross-connect systems or plants when possible. Carry out applicable casualty control procedures in the event of damage to machinery or piping systems. Stop and lock the shaft in the event of serious damage to the turbine, the reduction gear, the main shaft, or the loss of lubricating oil pressure to the main engines. Use soft patches, blank flanges, wooden plugs, or other suitable means to repair lube oil lines, freshwater lines, saltwater cooling lines, auxiliary exhaust lines, and other low-pressure lines.

If a ruptured steam line prevents the entry of repair party personnel into a space, secure the space by using remote controls.

Take all precautions to prevent flooding of the space. Put all available pumps on the bilges of the damaged space. Plug all holes, and, if possible, prevent flooding of other spaces.

Extinguish fires and investigate damage. Make necessary repairs to return the machinery and the space back to service as soon as possible.

Keep communication lines open. You should keep main engine control advised of existing conditions.

DAMAGED CABLE AND EQUIPMENT

In any casualty involving damage to electrical cable and equipment, electrical circuits may be a hazard if they remain energized. The circumstances surrounding each case of damage will dictate action to be taken. In cases of serious damage, remove electrical power, when necessary, from all cables in the damaged area. This is to prevent the ignition of combustible liquids and gases. Continued operations, however, may require the reestablishment of power to undamaged circuits. This may include cables that extend through damaged areas.

Splices may be made or temporary jumpers may be run in some cases to reestablish power to the required circuits. Lighting circuits are not to be disregarded. This is because damage control activities can be seriously handicapped or rendered impossible by inadequate lighting.

Damaged electrical equipment should be isolated from all available sources of power. In the case of a damaged switchboard, all circuits feeding to the switchboard from remote sources should be de-energized. They should be tagged out of service at the source.

CASUALTY POWER SYSTEM

The casualty power system is limited to minimal electrical facilities required to keep the ship afloat in the event of damage and to get it out of a danger area. Important features of the casualty power system include the preservation of the watertight integrity of the ship, simplicity of installation and operation, flexibility of application, interchangeability of parts and equipment, minimum weight and space requirements, and the ability to accomplish the desired functions.

The casualty power system is a temporary means of providing power. It is not a means of making temporary repairs. The system is purposely limited in its scope to retain effectiveness. The more equipment that is added and the more the system is expanded, the greater will be the possibility of error in making connections. Also, the possibility of faults at relatively unimportant equipment can cause loss of power at vital equipment. It is also probable that the casualty power system, if expanded, would be burdened with miscellaneous loads at a time when its use would be essential for vital loads.

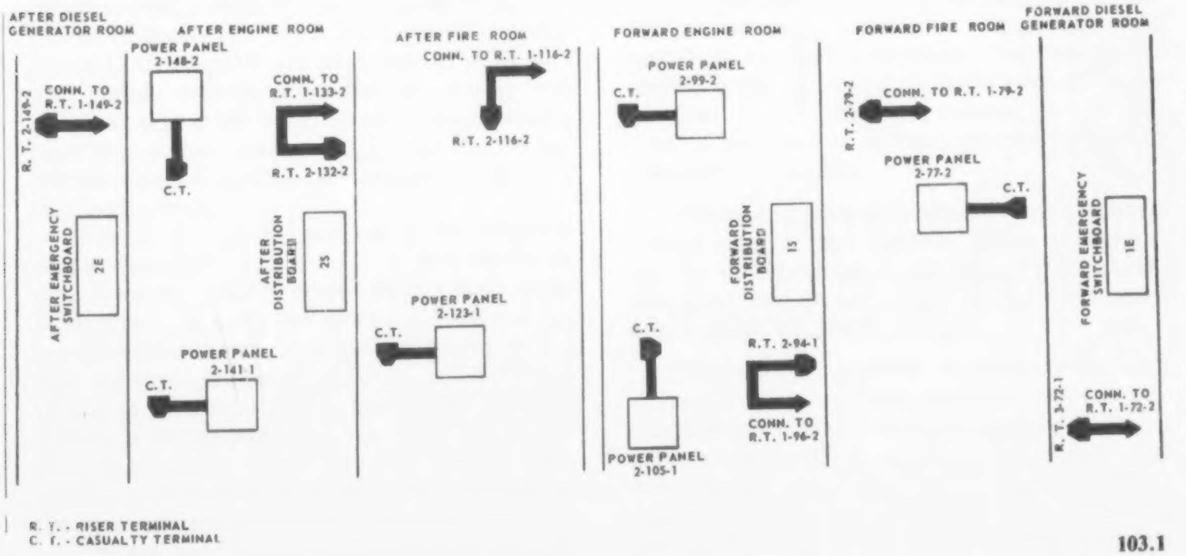
The electrical casualty power system in a typical destroyer is illustrated in the schematic diagram in figure 3-11. The system contains no permanently installed cables, except for vertical risers and bulkhead terminals. The risers are installed to carry circuits through decks without impairing the watertight integrity of the ship. A riser consists of a TSGA-60 cable extending from one deck to another with a riser terminal connected to each end for attachment of portable cables.

Portable THOF-42 cables in suitable lengths form all the circuits required to supply power to equipment designated to receive casualty power. While the normal current-carrying capacity of THOF-42 cables is 93 amperes, its casualty rating is 200 amperes. Under normal conditions, this cable will carry 200 amperes for 4 hours without damage to the cable.

The bulkhead terminals carry circuits through bulkheads without impairing the watertight integrity of the ship.

Power panels supplying equipment designated for casualty power service are equipped with terminals so that casualty power can be fed into the panels. These panels can also be used as a source of power for the casualty power system in the event that power is still available from the permanent feeders to the panels. However, the decision to take power from the panel instead of the switchboard should be based on knowledge that equipment on that panel will not be required for the safety of the ship. Operating the equipment that is normally supplied by the panel plus the equipment to be supplied with casualty power may cause an overload on the circuit breaker supplying the panel. Portable switches are located in several strategic positions throughout the ship for use with the casualty power system.

In general, the casualty power system provides a horizontal run of portable cable along the damage control deck with risers for the


AFTER DIESEL GENERATOR ROOM
AFTER ENGINE ROOM
AFTER FIRE ROOM
FORWARD ENGINE ROOM
FORWARD FIRE ROOM
FORWARD DIESEL GENERATOR ROOM
R. T. 2-149-2
CONN. TO R.T. 1-149-2
AFTER EMERGENCY SWITCHBOARD
2E
POWER PANEL 2-148-2
C.T.
CONN. TO R.T. 1-133-2
R.T. 2-132-2
AFTER DISTRIBUTION BOARD
2S
POWER PANEL 2-141-1
C.T.
CONN. TO R.T. 1-116-2
R.T. 2-116-2
POWER PANEL 2-123-1
C.T.
POWER PANEL 2-99-2
C.T.
FORWARD DISTRIBUTION BOARD
1S
C.T.
POWER PANEL 2-105-1
R.T. 2-94-1
CONN. TO R.T. 1-96-2
R.T. 2-79-2
CONN. TO R.T. 1-79-2
POWER PANEL 2-77-2
C.T.
FORWARD EMERGENCY SWITCHBOARD
1E
R. T. 3-72-1
CONN. TO R.T. 1-72-2
R. T. - RISER TERMINAL
C. T. - CASUALTY TERMINAL

103.1

Figure 3-11.—Electrical casualty power system.

power supply and for loads extending to and from this level. Rigging and unrigging casualty power cables are described in *Electrician's Mate 3 & 2*, NAVEDTRA 10546-E.

In figure 3-11, the ship's service switchboards 1S and 2S, and the emergency switchboards 1E and 2E, are provided with casualty power terminals installed on the back of the switchboard. Each casualty power terminal is connected to the buses through a standard 250-ampere AQB circuit breaker. The circuit breakers have an instantaneous (magnetic) trip element setting to prevent tripping of the generator breaker or fusing of the casualty power cable under short-circuit conditions. Connections to the buses are between the generator circuit breaker and disconnect switch.

MARINE GAS TURBINE DRIVE CASUALTIES

Operational casualties and corrective procedures for this type of drive may be found in *Marine Gas Turbine Operations*, NAVEDTRA 10097.

SUMMARY

You must remember that a casualty control program is only as good as you make it. The key word is "training."

The EOSS, EOP, and EOCC will take you a long way in correcting any casualties you might sustain. Your ECCET should include your very best personnel so they can pass along their knowledge to others. As has been stated in the past, "the more you sweat in peace, the less you bleed in war!"

REFERENCES

Boiler Technician 3 & 2, NAVEDTRA 10535-H

Boiler Technician 1 & C, NAVEDTRA 10536-F

Engineering Operation Sequencing System, OPNAVINST 9200.3

Engineering Administration, NAVEDTRA 10858-F

Damage Control, NAVSEA S9086-SN-STM-20, chapter 079

CHAPTER 4

VOLTAGE AND FREQUENCY REGULATION

Sophisticated electronics and weapons systems aboard modern Navy ships require closely regulated electrical power for proper operation. The increased demand for closely regulated power is being met by establishing new standards for a.c. shipboard power system. Also new voltage and frequency-regulating equipment has been developed. Following a brief discussion of the new standards and equipment, we will discuss in this chapter the various types of voltage regulators for a.c. generators in use aboard Navy ships. Also, we will discuss the SPR 400 in-line regulator.

TYPES I, II, AND III POWER

Mil-Std-761B (Ships) of 15 July 1965 established standard electrical characteristics for a.c. power systems. The three basic power supplies (types I, II, and III) are described in table 4-1. The power system characteristics shown are those existing at the load. They do not represent generator output characteristics. All figures are the maximum allowable percentages or times for that type power.

Present ship service generators and distribution systems are adequate for 60 and 400 hertz type I power. Type II power differs principally from type I. Type II has more stringent voltage requirements. Better voltage regulation at the ship service generator will not satisfy these voltage requirements. This is because the specified voltage is at the equipment or load, not at the generator output. Static type line voltage regulators which provide type II voltage control at the load are discussed in the chapter.

Voltage and frequency requirements for type III power cannot be met without isolating the equipment requiring the power from the rest of the power system. Motor generator sets are normally used for this purpose.

TYPES OF VOLTAGE REGULATORS

A voltage regulator consists of a control element and mechanical or electrical means to produce the changes in the generator field current. These changes are necessary to maintain a predetermined constant generator terminal voltage. When used on d.c. generators, voltage regulators and their auxiliary equipment maintain the generator terminal voltage within specified limits. They also provide proper division of the load between generators operating in parallel. When used on a.c. generators, voltage regulators, and their auxiliary equipment, they function to maintain the generator terminal voltage within specified limits. They also provide proper division of the reactive current between generators operating in parallel.

The types of voltage regulators used in naval vessels are (1) the indirect acting rheostatic, (2) the direct acting rheostatic, (3) the rotary amplifier, and (4) the combined static excitation and voltage regulation system.

One voltage regulator is provided for each generator to be regulated. In some ship's service installations a spare voltage-sensitive (control) element is installed on the switchboard. The switchboard is provided with a transfer switch. This allows the spare element to be placed in service if either of the other control elements become disarranged. Spare control elements are

Table 4-1.—Standard Electrical Characteristics for Shipboard A.C. Power Systems

Voltage	Type I	Type II	Type III
(a) Nominal user voltage, volts rms	440 or 115	440 or 115	440, 115 or 115/200 (see note 1)
(b) User voltage tolerances			
(1) Steady state voltage (see figures 2 through 7)			
a. Average of the three line-to-line voltages	±5%	±5%	+1/2%
b. Any one line-to-line voltage including a. above and line voltage unbalance tolerance	±7%	±7%	±1 1/6%
(2) Line voltage unbalance	3%	3%	1%
(3) Voltage modulation	2%	2%	1%
(4) Voltage transient			
a. Voltage transient limits	±16%	±16%	±5%
b. Voltage transient recovery time, seconds	2	2	0.25
(5) Voltage spike (peak value) volts	2500	2500	2500
(6) The maximum worst case departure from nominal user voltage resulting from (b) (1) and (b) (3) combined, except under transient or fault conditions.	±6%	±6%	±1%
(7) The worst case voltage excursion from nominal user voltage resulting from (b) (4) a, (b) (1) a. and (b) (3) combined except under fault conditions–see note 2	±20%	±20%	5 1/2%
Waveform			
(c) Total harmonic distortion	5%	5%	3%
(d) Maximum single harmonic	3%	3%	2%
(e) Deviation factor	5%	5%	5%
Frequency			
(f) Nominal frequency (Hertz)	60	400	400
(g) Frequency tolerances			
(1) Steady state frequency	±3%	±5%	±1/2%
(2) Frequency cyclic variation	+1/2%	1/2%	1/2%
(3) Frequency transient	±4%	±3%	±1%
(4) Frequency transient recovery time, seconds	2	2	0.25
(5) The worst case frequency excursion from nominal frequency resulting from (g) (1), (g) (2), and (g) (3) combined, except under fault conditions	5-1/2%	6-1/2%	1-1/2%
Power Continuity			
(h) Typical power interruption time, seconds	0.5 to 20	0.5 to 20	0.5 to 3

Notes:

1. When a 115/200 volt, 3 phase 4 wire, wye system is supplied from line voltage regulators, the type III characteristics apply to line-to-neutral power. Line to line power characteristics may be expected to exceed these limits under certain conditions. 115/200 volt power is only supplied for aircraft servicing and avionics ships.
2. Excursions of this magnitude will only occur infrequently.

not installed for voltage regulators used on emergency generators.

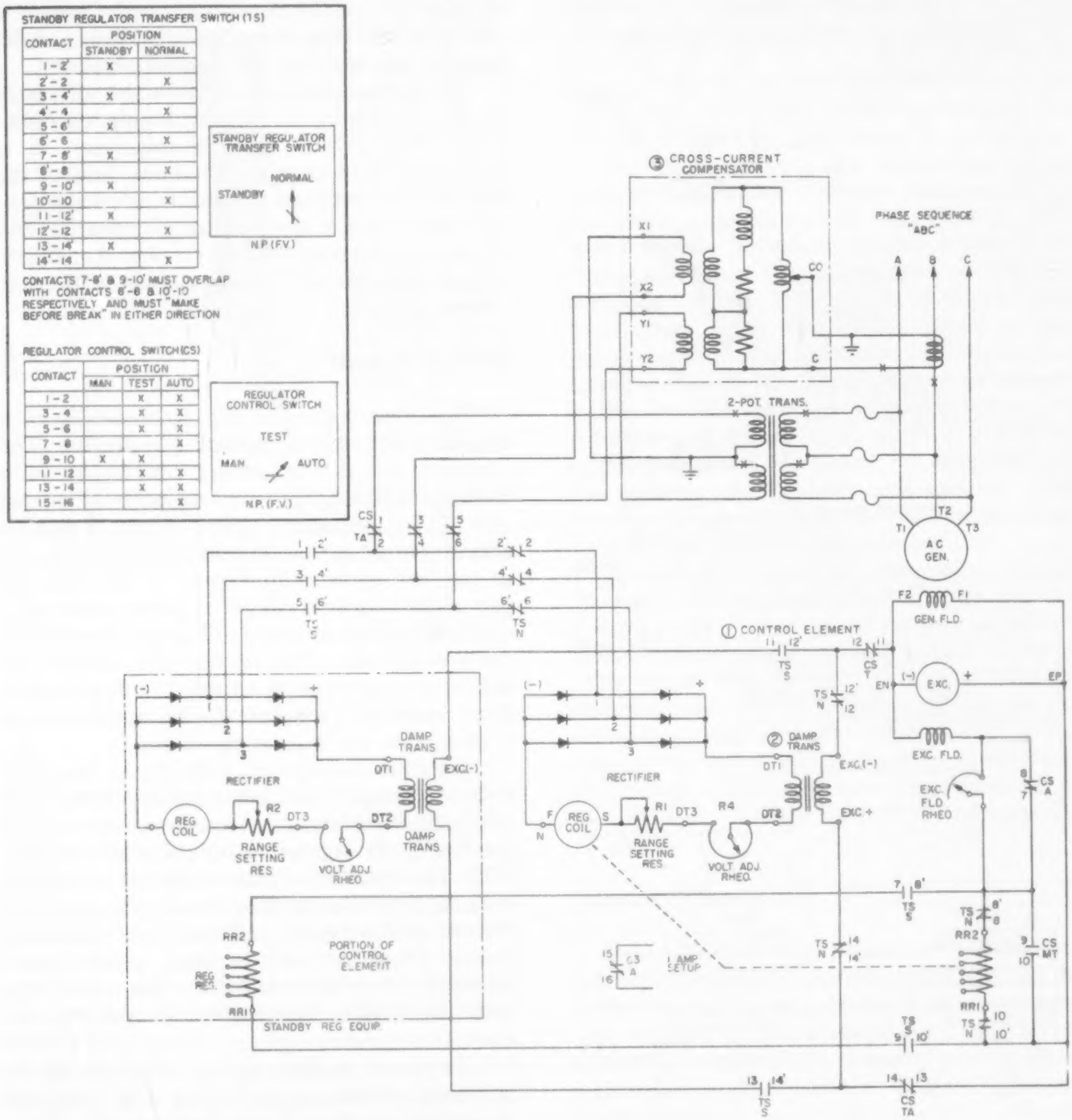
INDIRECT ACTING RHEOSTATIC VOLTAGE REGULATOR

The indirect acting rheostatic type voltage regulators were used on all a.c. ship's service generators and many emergency generators until 1943. Very few of these voltage regulators are still in service. They will not be discussed in this manual.

DIRECT ACTING RHEOSTAT VOLTAGE REGULATOR

The direct acting rheostatic type voltage regulator consists of a control element in the form of a regulator coil which exerts a mechanical force directly on a special type of regulating resistance.

The installation of direct acting (silverstat type) voltage regulators used on emergency a.c. generators is illustrated by the schematic diagram in figure 4-1. As stated previously, in



STANDBY REGULATOR TRANSFER SWITCH (TS)

CONTACT	POSITION	
	STANDBY	NORMAL
1 - 2'	X	
2' - 2		X
3 - 4'	X	
4' - 4		X
5 - 6'	X	
6' - 6		X
7 - 8'	X	
8' - 8		X
9 - 10'	X	
10' - 10		X
11 - 12'	X	
12' - 12		X
13 - 14'	X	
14' - 14		X

CONTACTS 7-8' & 9-10' MUST OVERLAP WITH CONTACTS 8'-8 & 10'-10 RESPECTIVELY AND MUST "MAKE BEFORE BREAK" IN EITHER DIRECTION

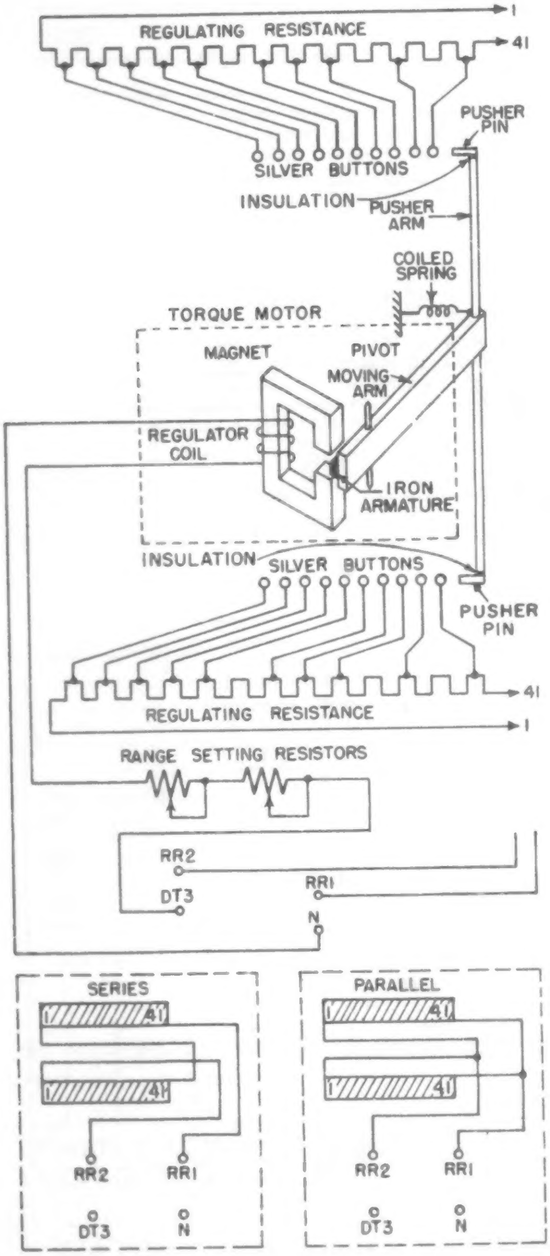
REGULATOR CONTROL SWITCH (CS)

CONTACT	POSITION		
	MAN	TEST	AUTO
1 - 2		X	X
3 - 4		X	X
5 - 6		X	X
7 - 8			X
9 - 10	X	X	
11 - 12		X	X
13 - 14		X	X
15 - 16			X

STANDBY REGULATOR TRANSFER SWITCH
STANDBY
NORMAL
N.P.(F.V.)
REGULATOR CONTROL SWITCH
TEST
MAN
AUTO
N.P.(F.V.)
③ CROSS-CURRENT COMPENSATOR
X1
X2
Y1
Y2
CO
C
PHASE SEQUENCE "ABC"
A
B
C
2-POT. TRANS.
T1
T2
T3
AC GEN.
F2
F1
GEN. FLD.
① CONTROL ELEMENT
(-)
EXC.
+
EN
EP
EXC. FLD.
EXC. FLD. RHEO
CS A
CS MT
CS TA
TS S
TS N
② DAMP TRANS
DT1
DT2
DT3
EXC.(-)
EXC.+
RECTIFIER
REG COIL
R1
R2
R4
RANGE SETTING RES
VOLT. ADJ. RHEO.
DAMP TRANS
RR2
RR1
REG RES.
PORTION OF CONTROL ELEMENT
STANDBY REG EQUIP.
CS A
LAMP SETUP
F
S
N

27.20

Figure 4-1.—Schematic diagram of direct acting voltage regulator installation.


REGULATING RESISTANCE
1
41
PUSHER PIN
SILVER BUTTONS
INSULATION
PUSHER ARM
COILED SPRING
TORQUE MOTOR
MAGNET
PIVOT
MOVING ARM
REGULATOR COIL
IRON ARMATURE
INSULATION
SILVER BUTTONS
PUSHER PIN
41
REGULATING RESISTANCE
1
RANGE SETTING RESISTORS
RR2
DT3
RR1
N
SERIES
1
41
1
41
RR2
RR1
DT3
N
PARALLEL
1
41
1
41
RR2
RR1
DT3
N

111.25

Figure 4-2.—Control element of direct acting voltage regulator.

each installation one regulator controls one a.c. generator. When a standby regulator is installed, a standby regulator transfer switch is also installed. This allows for substituting of the standby regulator for the normal regulator.

The voltage regulator controls the voltage of the d.c. exciter by the variable regulating resistance. This is built into the regulator. It is connected in series with the shunt field of the exciter. The complete regulator includes a control element (1), a damping transformer (2), and a cross-current compensator (3). The d.c. exciter in turn controls the voltage output of the a.c. generator.

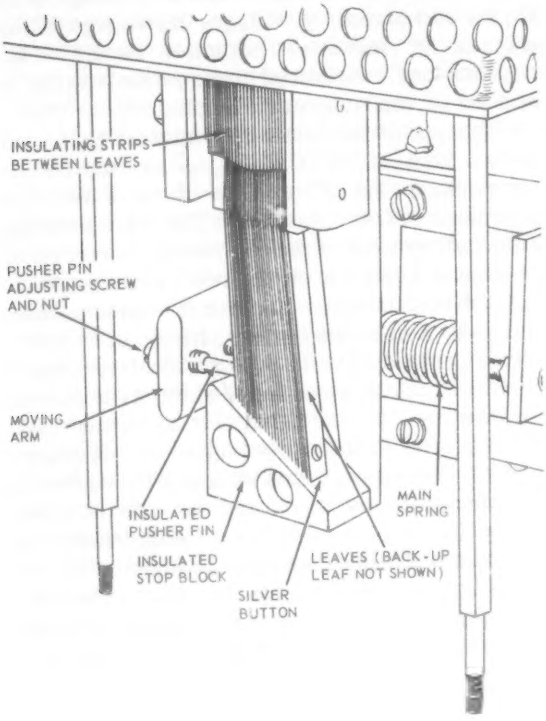
Control Element

The control element (fig. 4-2) consists of a regulator coil and a regulating resistance. The regulator coil is a stationary coil wound on a C-shaped iron core with a spring-mounted moving arm. The nonmagnetic spring-mounted moving arm is pivoted so that an iron armature attached to one end is centrally located in the fixed air gap of the magnetic circuit. A pusher arm and a coiled spring are attached to the the other end of the moving arm. The pusher arm carries two insulated pusher points arranged to bear against silver buttons. These are spring mounted and connected to the regulating resistance.

The silver buttons are individually mounted on leaf springs. They are insulated from each other. They are connected to consecutive taps on the stationary regulating resistance plates (fig. 4-3). The resistance plates consist of tapped resistance wire embedded in vitreous enamel. The control element includes two resistance plates. There is one for each silver button assembly. They are mounted in the rear of the unit. The silver buttons connect to taps from the associated resistance plate.

The control element also includes two adjustable range-setting resistors (fig. 4-2). They are connected in series with the regulator coil. These resistors are used to set the range (covered by the voltage adjusting rheostat) so that rated generator voltage is obtained with the voltage adjusting rheostat in the midposition.

The primaries of two potential transformers, connected in open delta, are connected across the terminals of the a.c. generator (fig. 4-1). The


INSULATING STRIPS BETWEEN LEAVES
PUSHER PIN ADJUSTING SCREW AND NUT
MOVING ARM
INSULATED PUSHER PIN
INSULATED STOP BLOCK
SILVER BUTTON
LEAVES (BACK-UP LEAF NOT SHOWN)
MAIN SPRING

111.26

Figure 4-3.—Silver button assembly.

secondaries of these transformers are connected to a three-phase, full-wave rectifier through the compensator. The d.c. output of the rectifier is applied to the series circuit. This consists of the regulator coil, range-setting resistance, voltage adjusting rheostat, and secondary of the damping transformer. In the following description of operation, note that the standby regulator on the left side of the schematic (fig. 4-1) is not energized or used.

When the regulator coil is energized, the magnetic pull on the iron armature is balanced against the mechanical pull of the coiled spring. If the magnetic pull of the armature overcomes the pull of the spring, all of the silver buttons are separated from each other. This causes maximum resistance in the field circuit. Conversely, if the tension of the coiled spring overcomes the pull of the armature, the silver buttons are pressed together. This shorts out the resistance in the field circuit. Thus, the moving arm operates through its travel, depending on the direction of motion, to successively open or close the silver buttons. This increases or decreases the resistance in the exciter field. The moving arm has a short travel so that all resistance can be inserted or cut out quickly. It can also be varied gradually. This depends on the required change in excitation.

For example, when the alternating voltage rises, the regulator operates because of the increasing magnetic pull on the armature. This action inserts resistance in the exciter field circuit to reduce the exciter field current and armature voltage. The primary of the damping transformer across the exciter circuit is subjected to this change in current. Through transformer action, a momentary voltage is induced in the secondary that opposes the increase in regulator coil current. This action is a form of negative feedback. It lowers the magnitude of the increase in regulator coil current. This restricts the magnitude of the decrease in exciter field current and armature voltage.

Conversely, when the alternating voltage decreases, the regulator operates in the opposite direction. This is because of the pull exerted by the coiled spring. This action shorts out resistance in the exciter field circuit. The impulse from the damping transformer momentarily opposes the decrease in regulator coil current. This action reduces the extent of the decrease in regulator coil current. This then restricts the magnitude of the increase in exciter field current and armature voltage.

Damping Transformer

The damping transformer is an antihunt device. It consists of two windings placed on the center leg of a C-shaped laminated iron core. The primary of this transformer is connected across the output of the exciter (fig. 4-1). When a change occurs in the exciter voltage, the primary of the damping transformer induces a voltage in its secondary. The secondary voltage acts on the regulator coil to dampen the movement of the armature. This prevents hunting and excessive changes in the generator terminal voltage.

The voltage-adjusting rheostat (fig. 4-1) is used to raise or lower the regulated value of the a.c. generator voltage.

The regulator control switch has three positions: manual, test, and automatic.

When the control switch is in the MANUAL position, you can control the a.c. generator voltage manually by the EXCITER FIELD rheostat (fig. 4-1).

When the control switch is in the TEST position (as shown), the control element is energized. However, the regulating resistance is shorted out. The current in the exciter field circuit can be varied by the exciter field rheostat. The operation of the moving arm in the control element can be observed.

When the control switch is in the AUTOMATIC position, the generator is under full control of the regulator. The regulator will adjust the voltage to the value predetermined by the position of the voltage-adjusting rheostat.

When operating the control switch from the MANUAL to the AUTOMATIC position, you should pause in the TEST position. This allows the transient current in the regulator coil circuit to disappear without effecting the a.c. generator output voltage. The transient current is caused by the sudden connection of the damping transformer primary across the exciter armature.

Cross-Current Compensator

When two or more regulator-controlled a.c. generators operate in parallel on the same bus, you must equalize the amount of reactive current carried by each generator. This equalization of reactive current is accomplished by giving the regulator a drooping characteristic. This is done by a cross-current compensator provided with each a.c. generator and associated regulator.

The compensator (fig. 4-1) consists of a tapped autotransformer connected across a resistor-reactor combination. The autotransformer is energized from a current transformer. It is connected in the B phase of the a.c. generator between the generator terminals and the bus. Two isolation transformers, with a 1-to-1 ratio, pick up the voltage drops from the resistor-reactor combination. The output potential terminals of these transformers (X1, X2 and Y1, Y2) are connected in series with the a.c. potential leads. These leads are between the secondaries of the two 440/110-volt open delta potential transformers and the three-phase, full-wave rectifier. This rectifier supplies direct current for the regulator coil. The compensator is designed to supply compensating voltages in two legs of the three-phase regulator potential circuit. This ensures that a balanced three-phase voltage is applied to the regulator element.

The taps on the autotransformer are connected to two DIAL SWITCHES (not shown) on the compensator faceplate. One of these switches provides a coarse adjustment. The other provides a fine adjustment of the compensator. A total of 24 steps is available on the two switches. In the case of the standard 12-percent compensation, this gives a one-half percent change in compensation per step. The 12-percent compensation is based on four amperes supplied from the current transformer. If the current transformer ratio should give some other value of secondary current, the compensation settings will be affected proportionally. You should set the compensating droop introduced by the compensator to approximately 6 percent from no load to full load at 0.8 lagging power factor. However, when you have made the proper connections and settings, no further adjustments should be necessary.

Operation

When the generator circuit breaker is closed and the control switch is in the AUTOMATIC position, the generator is under control of the voltage regulator (fig. 4-1). If the a.c. generator voltage is normal, the regulator moving arm is at rest in a balanced state.

If an additional load is placed on the generator, the terminal voltage will drop. An increase in the exciter field current is then required to increase the generated voltage and to restrict the fall in terminal voltage.

The decrease in generator terminal voltage is transmitted through the 440/110-volt potential transformers and the rectifier. This decreases the magnetizing effect of the regulator coil. The pull of the coiled spring overcomes the magnetic pull on the armature. This moves the arm in a direction that begins closing more of the silver buttons in sequence. This action shorts out (in small steps) additional positions of the regulating resistance. This resistance is connected in the exciter field circuit. This causes the exciter field current to be increased and the a.c. generated voltage to be raised. This action prevents a further decrease in the terminal voltage. When the voltage decrease is checked, the moving arm of the regulator is again in a balanced state. The position of the regulator moving arm, however, has changed to correspond to the increase in load on the generator.

If some load is removed from the generator, this causes the terminal voltage to rise. A decrease in the exciter field current is then required to restore the voltage to normal. The increase in terminal voltage increases the magnetizing effect of the regulator coil. The magnetic pull on the armature then overcomes the pull of the coiled spring. This moves the arm in a direction to begin separating, in sequence, more of the silver buttons. This action inserts (in small steps) additional portions of the regulating resistance. This causes the exciter field current to decrease and the a.c. generated voltage to lower. The rise in terminal voltage is then restricted to a small value.

The Silverstat voltage regulator can increase the excitation to the ceiling voltage of the exciter. It can also reduce the excitation to the lowest value required. Because total travel of the moving arm is only a fraction of an inch, the regulating resistance can be easily varied. This depends upon the requirements of the operating conditions.

To place the voltage regulator in control for the first time, be certain that the generator line circuit breaker is open. Then, turn the regulator control switch to the MANUAL position. Turn the exciter field rheostat in the direction to lower the voltage. Then turn the voltage adjusting rheostat to a position midway between the lower and raised ends of its travel. After bringing the generator and exciter up to speed, turn the exciter field rheostat gradually in the direction that raises the voltage. At the same time, observe the a.c. generator voltmeter. When the voltmeter indicates the rated a.c. generator voltage, stop turning the rheostat.

To place the regulator in control of the a.c. generator voltage, turn the regulator control switch from the MANUAL to the TEST position. Pause for two or three seconds. Then turn the switch to the AUTOMATIC position. Next turn the voltage adjusting rheostat until the a.c. generator reaches the rated value. After this condition has been obtained, the regulator moving arm should settle promptly after a load or voltage change. (If the arm should swing back and forth continuously, check the polarity of the damping transformer terminals. The wrong polarity or an open circuit will cause this violent swinging.) When the generator voltage is approximately at rated value, close the generator circuit breaker if the generator is operating alone.

If operated in parallel with a generator already connected to the bus, close the circuit breaker of the incoming generator only when the two outputs are in synchronism. The incoming generator can be connected to the line with the regulator control switch in the NORMAL or AUTOMATIC position. As soon as the two generators are operating in parallel, readjust the governor motor (speed-changer) until each unit takes its share of the kilowatt load.

To shut down the unit, remove the kW load on the generator by turning the governor motor control rheostat while observing the wattmeter. If necessary turn the voltage adjusting rheostat in a direction to reduce the reactive load. As the load approaches zero, open the generator line circuit breaker.

Maintenance

In addition to the actions shown on the maintenance requirement cards and the instructions given in the voltage regulator technical manuals, routine maintenance should include ensuring that connections are tight and strictly in accordance with installation diagrams. This maintains the effective resistance in the shunt field circuit of the exciter. You should also ensure that the operation of the silver buttons is smooth throughout the entire travel of the movable core.

It would be advisable to review the information about silver contacts in *Electrician's Mate 3 & 2*, NAVEDTRA 10547-D1. Contacts made of silver or its alloys conduct current when discolored (blackened during arcing) with silver oxide. This discolored condition therefore requires no filing, polishing, or removing.

ROTARY AMPLIFIER VOLTAGE REGULATOR

The rotary amplifier (amplidyne) type of voltage regulator uses a special type of exciter.

It furnishes a large change in output voltage for a small change in the control field current of the exciter. The control element detects variation of the a.c. generator voltage from a reference voltage. This can be set to a predetermined value. The variation between the actual alternating voltage and the reference voltage sends a current through the control field of the exciter. This changes its output voltage current and hence, changes the a.c. generator field current. This holds the alternating voltage at the desired value.

The complete amplidyne voltage regulator equipment consists of an amplidyne exciter (1), a pilot alternator (2), a stabilizer (3), a voltage-adjusting unit (4), an automatic control unit (5), a manual control unit (6), and a potential unit (7). This is illustrated by the block diagram in figure 4-4. Some installations include two normal voltage regulators and one standby regulator for two a.c. generators.

A cutout switch with two positions (manual and automatic) is provided for each generator. This switch is used to connect the amplidyne exciter and the regulator for either manual or automatic control of the a.c. generator voltage.

A transfer switch with three positions (NORMAL, GEN A, and GEN B) is also provided. This permits substituting the standby voltage regulator for either of the two normal regulators.

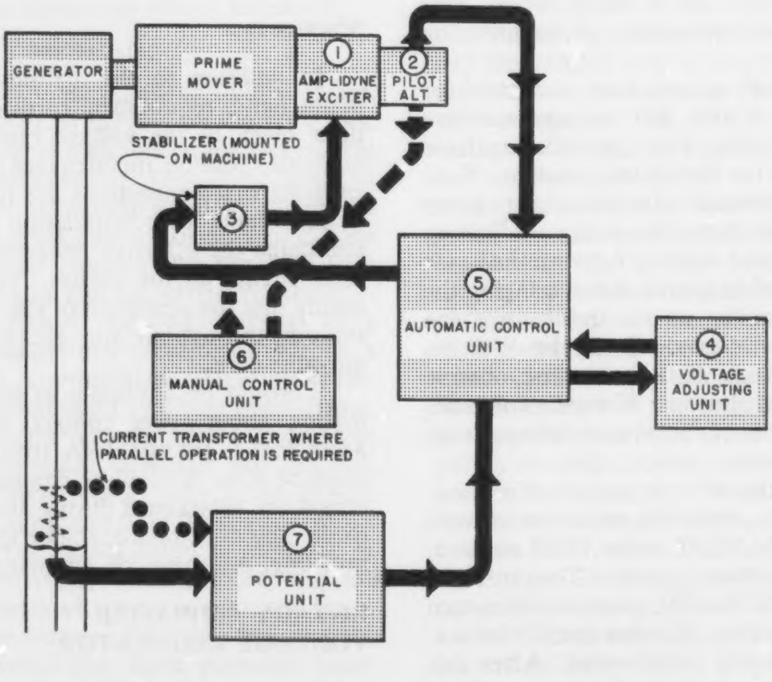
In the NORMAL position, generators A and B are connected in the normal automatic voltage control circuits of their respective regulators. The standby regulator is disconnected.

In the GEN A position, the standby regulator has taken control from the normal regulator of generator A. Generator B is connected to its normal regulator.

In the GEN B position, the standby regulator has taken control from the normal regulator of generator B. Generator A is connected to its normal regulator.

Amplidyne Exciter

The amplidyne exciter (fig. 4-4) is a rotary amplifier that responds quickly to small changes in


GENERATOR
PRIME MOVER
① AMPLIDYNE EXCITER
② PILOT ALT
STABILIZER (MOUNTED ON MACHINE)
③
⑤ AUTOMATIC CONTROL UNIT
④ VOLTAGE ADJUSTING UNIT
⑥ MANUAL CONTROL UNIT
CURRENT TRANSFORMER WHERE PARALLEL OPERATION IS REQUIRED
⑦ POTENTIAL UNIT

111.27

Figure 4-4.—Block diagram of amplidyne voltage regulator system.

control field current to cause large changes in output. It is mounted on the shaft of the prime mover. It provides the excitation for the a.c. generator.

Pilot Alternator

A voltage regulator requires a "reference" or standard to which the voltage being regulated may be compared. This determines whether or not the regulator should act to change the excitation of the a.c. generator. In direct acting voltage regulator, discussed above, the reference is provided by a coiled spring. In the amplidyne voltage regulator, the reference is provided by a "boost" current. This current is approximately 0.5 ampere from the pilot alternator. The pilot alternator (fig. 4-4) is a small permanent-magnet, single-phase a.c. generator, mounted on an extension of the amplidyne shaft. The effective voltage output of the pilot alternator is essentially constant.

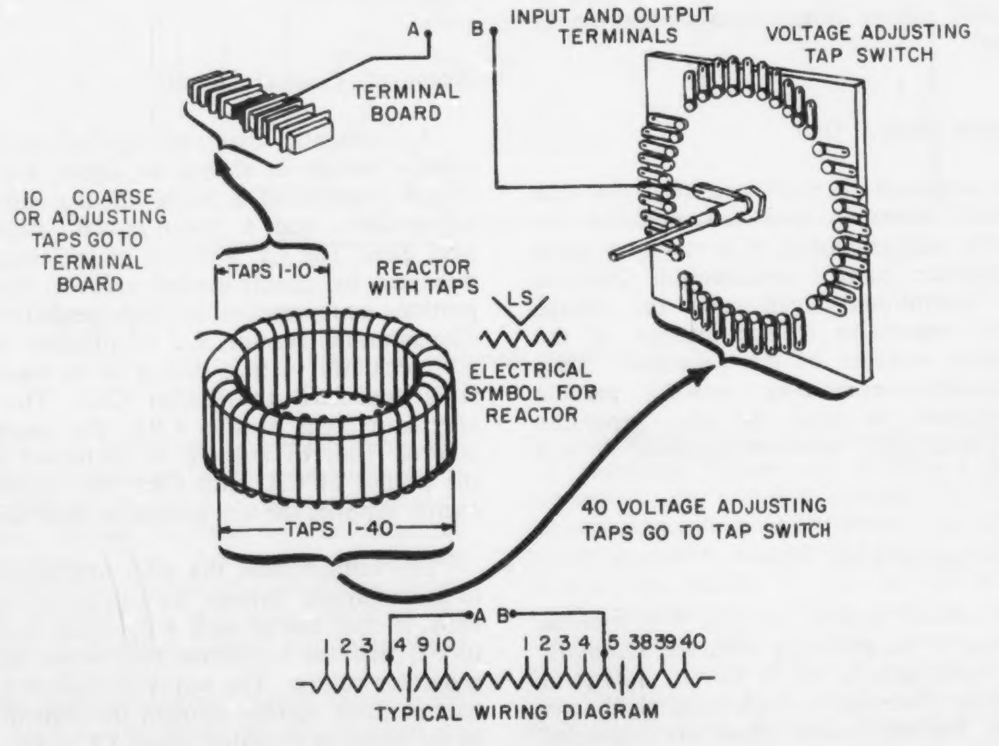
Stabilizer

The stabilizer (fig. 4-4) is mounted on or near the amplidyne exciter. It prevents sustained oscillations in generator output. It is essentially a transformer. However, because it is in a d.c. circuit, the stabilizer functions only when there is a change in the exciter voltage. The secondary winding is connected in series with the control field of the amplidyne exciter.

When the regulator operates to change the exciter voltage, a voltage is induced in the control field circuit through the stabilizer. This momentarily affects the control field current to restrain the regulator from making excessive correction of the exciter voltage. This prevents hunting.

Voltage-Adjusting Unit

The voltage-adjusting unit provides a.c. generator voltage that the regulator will maintain. This unit (fig. 4-5) consists of a tap switch and


A
B
INPUT AND OUTPUT TERMINALS
VOLTAGE ADJUSTING TAP SWITCH
TERMINAL BOARD
10 COARSE OR ADJUSTING TAPS GO TO TERMINAL BOARD
TAPS 1-10
REACTOR WITH TAPS
LS
ELECTRICAL SYMBOL FOR REACTOR
TAPS 1-40
40 VOLTAGE ADJUSTING TAPS GO TO TAP SWITCH
A B
1 2 3
4 9 10
1 2 3 4
5 38 39 40
TYPICAL WIRING DIAGRAM

111.28

Figure 4-5.—Voltage-adjusting unit.

a tapped saturated reactor. It mounts directly behind the generator control panel. The handle of the tap switch is on the front of the panel. The saturated reactor is the main component of the voltage-adjusting unit. It is the heart of the regulator system.

The saturated reactor determines the a.c. generator voltage that the regulator will maintain. It consists of a tapped coil of approximately 400 turns wound on a soft iron core. The core is operated in the saturated region so that a very small change in the applied voltage and flux density will produce a large change in coil current.

Changing the taps on the coil changes the reactance of the coil circuit. It also changes the voltage level held by the regulator. Increasing the turns (to a higher tap number) increases the reactance and voltage required to maintain a given coil current. Conversely, decreasing the turns decreases the reactance and voltage required to maintain the current. Tap changing is done only during original installation or an overhaul.

Automatic Control Unit

The automatic control unit (fig. 4-4) has the static elements that are required for automatic voltage control. It is mounted inside the generator control switchboard. Portions of the control-unit circuit make the voltage regulator responsive to the average of the three-phase voltages of the generator. Also, a frequency-compensating network permits the regulator to hold the a.c. generator voltage practically constant between 57 and 63 hertz.

Manual Control Unit

The manual control unit (fig. 4-4) controls the voltage of the generator when the automatic control equipment is not in use. It consists of two resistor plates and a single-phase, full-wave rectifier. The two resistor plates are connected as a rheostat and a potentiometer, which operate concentrically. The manual control unit is mounted inside the switchboard. The operating handwheels protrude through the front of the panel. The large handwheel provides coarse voltage adjustment. The small handwheel is used for fine or vernier adjustment.

Potential Unit

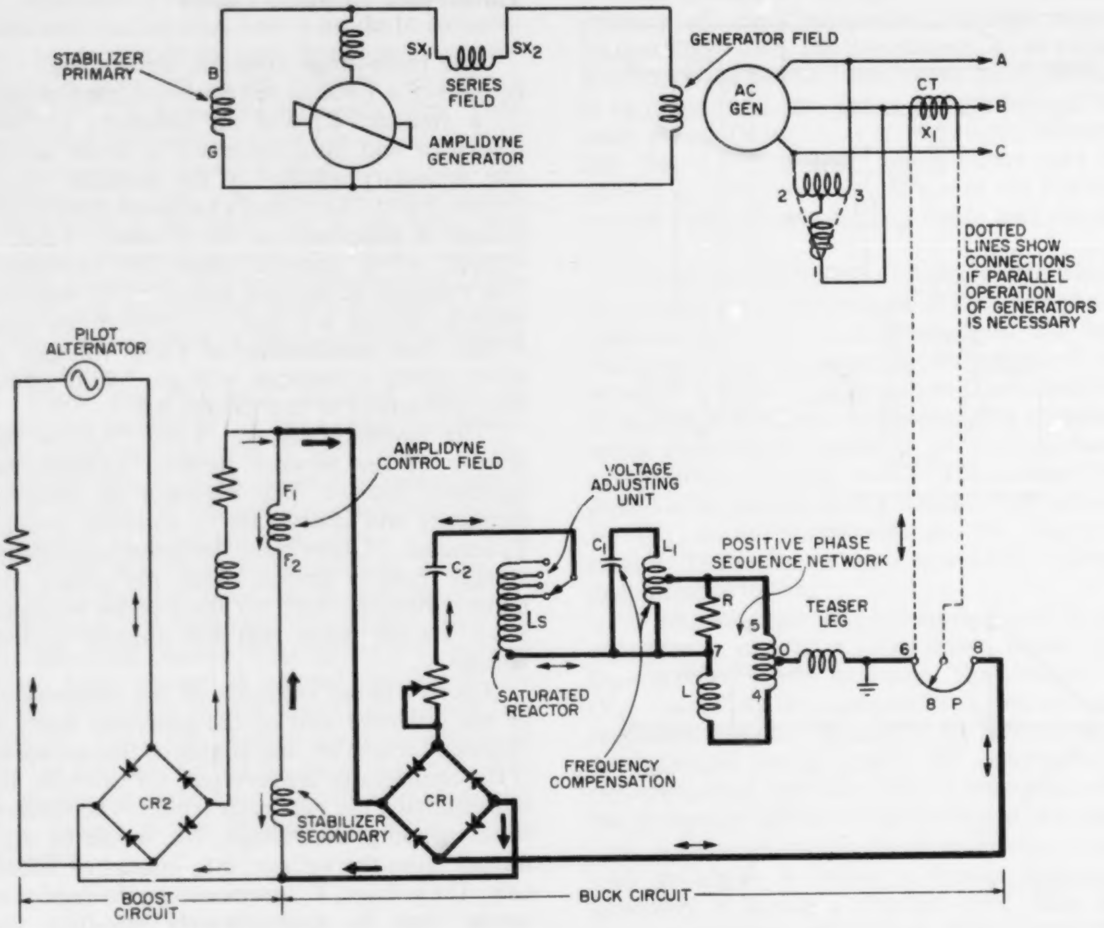
The potential unit (fig. 4-4) provides signal voltage to the regulator. This voltage is proportional to the voltage of the a.c. generator. The unit has a potential transformer and a potentiometer rheostat. The unit is mounted inside the generator switchboard near the current transformer and the generator circuit breaker.

The potential transformer is a special T-connected, 450-volt transformer. The potentiometer rheostat is connected in the circuit of a current transformer. It is used to provide the reactive load division between generators operating in parallel.

Automatic Control Circuit

A schematic diagram of the automatic control circuit is shown in figure 4-6. The circuit consists of a buck circuit, shown in heavy lines, and a boost circuit, shown in light lines. The a.c. portions of the circuit are indicated by double-headed arrows. The d.c. portions are represented by single-headed arrows. The saturated reactor, Ls, is energized by the a.c. generator voltage that is to be regulated. It is connected to rectifier CR1. The pilot alternator feeds rectifier CR2. The amplidyne control field, F1 and F2, is connected across the output of CR1 and CR2. The amplidyne exciter supplies the a.c. generator field directly.

The voltage from the pilot alternator tries to force current through the amplidyne control field. It does this in such a direction (from F1 to F2) that the amplidyne will boost the a.c. generator voltage. The saturated reactor circuit tries to force current through the control field in the opposite direction (from F2 to F1). This tends to decrease the generator voltage. When the a.c. generator voltage is near normal, the


STABILIZER PRIMARY
B
G
SX1
SX2
SERIES FIELD
AMPLIDYNE GENERATOR
GENERATOR FIELD
AC GEN
A
CT
B
X1
C
2
3
1
DOTTED LINES SHOW CONNECTIONS IF PARALLEL OPERATION OF GENERATORS IS NECESSARY
PILOT ALTERNATOR
AMPLIDYNE CONTROL FIELD
F1
F2
VOLTAGE ADJUSTING UNIT
C2
C1
L1
Ls
POSITIVE PHASE SEQUENCE NETWORK
R
5
7
L
4
0
TEASER LEG
6
8
8 P
SATURATED REACTOR
FREQUENCY COMPENSATION
CR2
CR1
STABILIZER SECONDARY
BOOST CIRCUIT
BUCK CIRCUIT

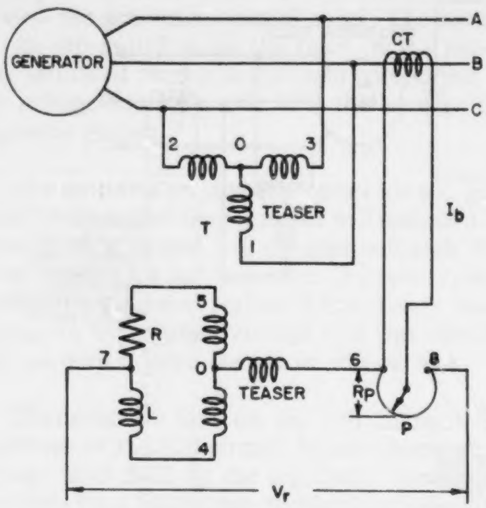
27.32

Figure 4-6.—Automatic control circuit.

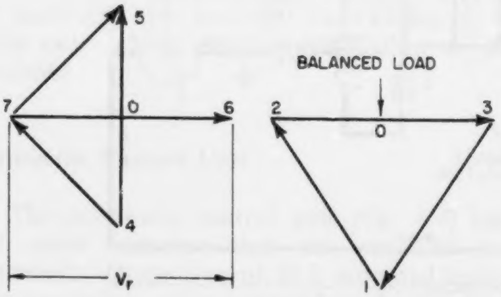
regulator is at its normal operating point. The boost current supplied by the pilot alternator is in the opposite direction. It is nearly equal to the buck current supplied by the saturated reactor circuit. Thus, the current through the control field is negligible. The amplidyne excitation is provided by the series field of the amplidyne to maintain normal terminal voltage of the a.c. generator.

If the generator voltage should drop slightly below normal, the buck current supplied by the saturated reactor would drop considerably. This action causes a boost current to flow in the control field. This tends to raise the a.c. generated voltage and prevents a further decrease in the terminal voltage. This action occurs because the pilot alternator is not affected by the generator voltage and is still trying to force a boost current through the control field.

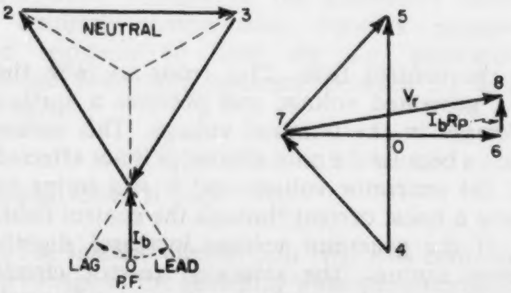
If the generator voltage increases slightly above normal, the saturated reactor circuit would pass a large additional current through the amplidyne control field. This tends to buck or decrease the a.c. generated voltage and prevents further increase in terminal voltage.



A. CIRCUIT



B. RESPONSE VECTORS



C. REACTIVE VECTORS

27.28:33

Figure 4-7.—Three-phase response circuit.

Three-Phase Response Circuit

The three-phase response circuit (fig. 4-7) consists of a T-connected potential transformer, T; a resistor, R; and an inductor, L. The resistance and inductance are in series across one secondary winding of the potential transformer (fig. 4-7A). When a balanced three-phase voltage is impressed on the primary, 1-2-3, a voltage, 4-5-6, appears across the secondary. The voltages across the inductor, L, and the resistor, R, are 4-7 and 7-5, respectively (fig. 4-7B). The relationship of these voltages is 4-7-5, giving a resultant voltage, 7-0, in phase with and added to the voltage 0-6.

The resulting voltage, 7-0-6 (V_r), is the voltage of the network used to energize the regulator circuits. The regulator at constant frequency will always act to maintain voltage V_r constant. If there is any deviation in generator voltage from its normal value, the system will make corrections until the three-phase voltages, 1-2-3, are the values that will produce normal voltage V_r.

Correct phase sequence of the connections of the potential unit to the generator leads is required for correct functioning of this network. If the connections are reversed, for example, by interchanging the two leads from the secondary teaser winding, the voltage, 7-0, would be subtracted from the voltage, 0-6, instead of added to it. The voltage, V_r, impressed on the regulator would then be approximately one-fifth the required value. Thus, the regulator in attempting to go to the ceiling voltage would overexcite the generator to abnormal levels.

Frequency Compensation

The reactance of the saturated reactor (fig. 4-6) increases as the frequency increases. Thus, an increase in frequency from 60 to 63 hertz at normal 100 percent voltage would decrease the buck current. The boost current would predominate so the regulator would tend to hold a higher voltage. A frequency lower than 60 hertz would have the opposite effect. This would tend to increase the buck current so it would predominate. The regulator would then tend to hold a lower voltage.

Therefore, a voltage regulator system using a saturated reactor must have a means to compensate for frequency changes. Frequency compensation is provided by an inductor, L1, and a capacitor, C1, in parallel with each other. They are across the resistance portion of the positive phase sequence network used for three-phase response (fig. 4-6). The values of the inductor and capacitor are such that at 60 hertz they provide a resonant parallel circuit. This acts like a high resistance. The other components of the system are adjusted so this resistance has no effect on the action of the regulator at normal frequency.

When the frequency increases above 60 hertz, the parallel circuit has a capacitive effect. This raises the apparent voltage "seen" by the saturated reactor. This causes it to pass as much buck current on normal voltage at the higher frequency as at normal frequency.

When the frequency decreases below 60 hertz, the parallel circuit has an inductive effect. This lowers the apparent voltage as "seen" by the saturated reactor. This causes it to pass as much buck current at normal voltages at the lower frequency than it would at normal frequency. Thus, the parallel circuit compensates for the frequency effect on the saturated reactor. It passes the same buck current at a particular line voltage at any frequency between 57 and 63 hertz.

Reactive Compensation

When a.c. generators are operated in parallel, division of the load between machines is a function of the governors of the prime movers. The division of the reactive load (KVA) is a function of the regulators, which increase or decrease the excitation of the generators.

The division of the reactive load (KVA) between generators (when operated in parallel) is accomplished by a compensating potentiometer, R, and a current transformer, CT, provided for each machine (fig. 4-7A). The rheostat is connected in series with the teaser leg of the T-connected potential transformer secondary. The current transformer is connected in the B phase of the generator. Its secondary is connected across one side of the potentiometer.

The generator voltage, 1-2-3, feeds the primary of the T-connected potential transformer (fig. 4-7A). The line current, I_b, of phase B in which the current transformer is connected, is in phase with the line-to-neutral voltage at unity power factor. I_b is at 90° to the voltage, 2-3 (fig. 4-7C). At any other power factor, current I_b swings out of phase with the line-to-neutral voltage depending on lag or lead conditions.

The secondary voltage, 7-6 (fig. 4-7B), which is the resultant output voltage of the three-phase response network, is in phase with the line voltage, 2-3, and is the voltage impressed on the saturated reactor. At unity power factor, current I_b produces a voltage, 6-8, across the compensating rheostat, R, which is 90° out-of-phase with voltage 7-6 (fig. 4-7C). The voltage 6-8 (I_bR_p) is the compensating voltage. The voltage 7-8 (V_r) is now impressed on the saturated reactor. The regulator tends to hold the voltage proportional to 7-8.

When two duplicate generators, A and B, are operating in parallel at rated power factor, the line-currents, I, will be equal. The voltage 7-8 (V_r) "seen" by the saturated reactors of both regulators will also be equal if the field currents are balanced (made equal), the compensating rheostats set at the same value of resistance, and the governors set for equal division of kilowatt load. Assume an instantaneous unbalance occurs with generator A having a weaker field and generator B having a stronger field. This unbalance can be caused by slight differences in the reactances or saturation characteristics of the generators or in the characteristics of the regulators. Because the excitation is unbalanced, there is a circulating current between the two generators. Their power factors are therefore unbalanced.

The effect of this unbalance distorts the voltage triangle, 7-6-8 (fig. 4-7C). The network voltage, 7-6, decreases slightly because of the drop in line voltage. The compensating voltage, 6-8 (I_bR_p), from the current transformer and the compensating rheostat have changed. This is because of the unbalanced line currents and power factors. Therefore, the compensating voltage, 6-8, for generator B is greater and at a different phase angle than the corresponding voltage for generator A. Thus, the resultant voltage, 7-8 (V_r), of the two machines is unequal and different from the original voltage that the regulators were set to hold constant.

The regulators will act to change the excitation of the two generators. This is done to restore the voltage, 7-8, to equal values of V_r for both regulators. They are set by changing the values of the field currents so they are balanced. The line currents and power factors will then be approximately balanced to give equal compensating voltages, 7-8. These voltages "seen" by the regulators for generators A and B, respectively, will then be equal to each other.

The regulator attempts to hold voltage V_r constant. Voltage, 7-8, depends on the value and phase angle of the compensating voltage, 6-8. The network voltage, 7-6, which is the difference between V_r and 6-8 and is proportional to the line voltage, has decreased slightly because of this change. Thus, the line voltage will be slightly less than that maintained before any change occurred to the system. This drop in line voltage resulted from the increase in reactive load current.

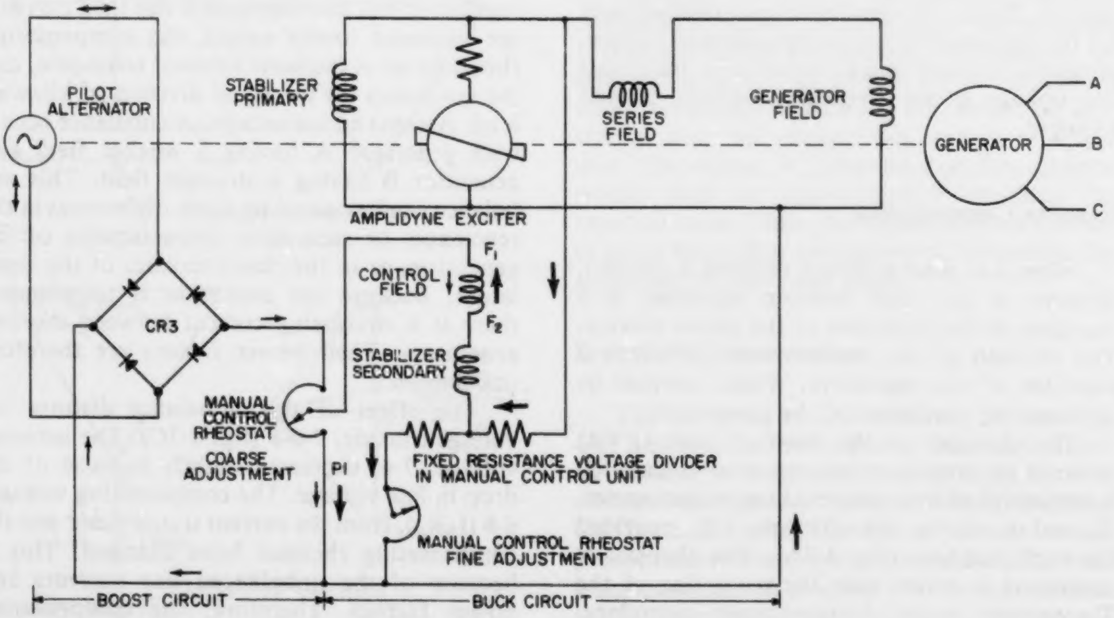
Manual Control Circuit

An elementary diagram of the manual control circuit is illustrated in figure 4-8. The buck and boost circuits are indicated by heavy and light arrows, respectively. The voltage that the amplidyne exciter will maintain across its terminals can be adjusted by the manual control rheostats. Thus, the a.c. generator terminal voltage can be varied. The manual control circuit is so designed that for any one setting of the manual control rheostat, the amplidyne terminal voltage applied to the generator field will remain constant.

Operation

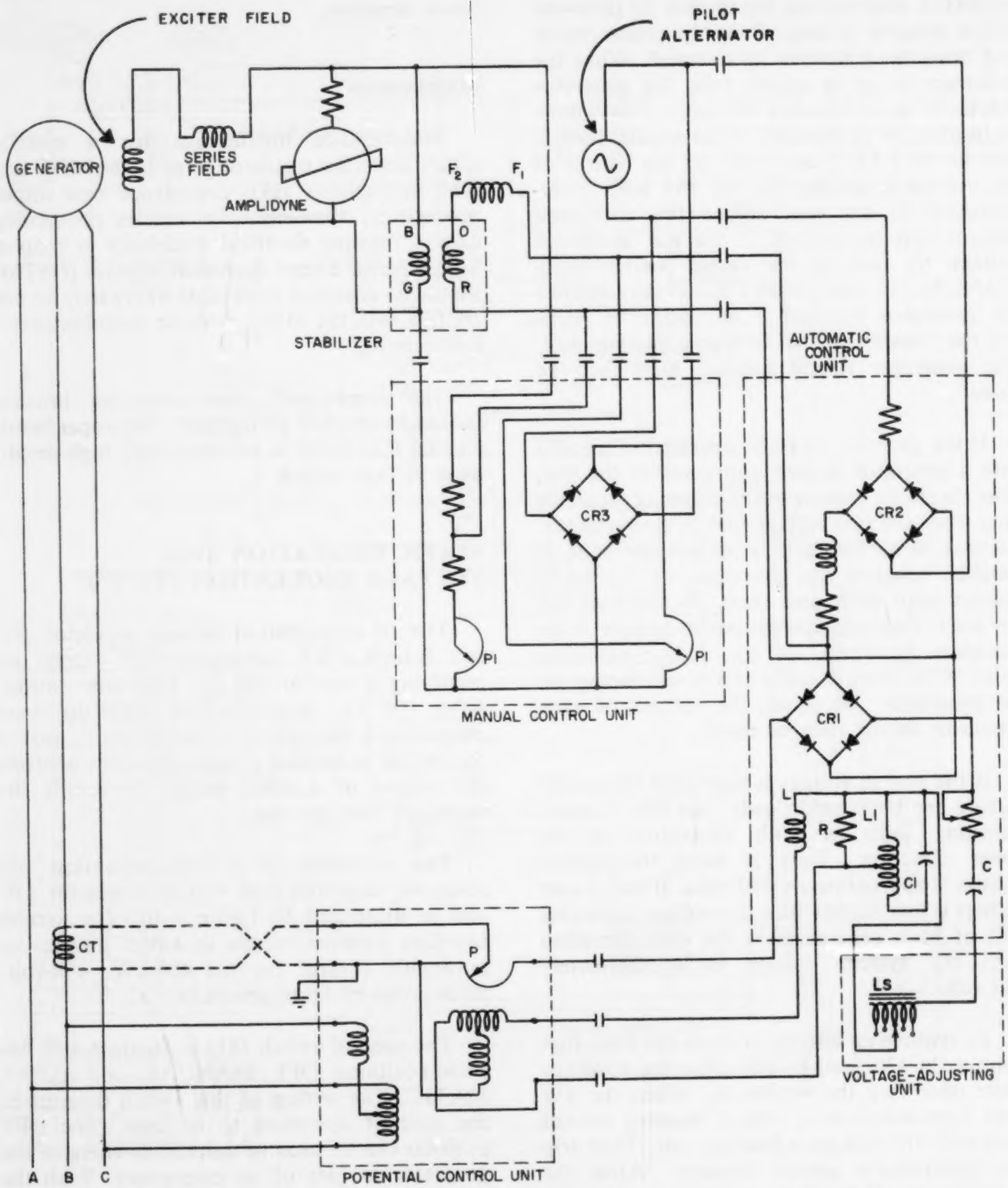
The schematic diagram of an amplidyne voltage regulator installation is illustrated in figure 4-9.

The normal operational sequence for a single generator is to set both handwheels of the manual control unit in the extreme LOWER position. Turn the regulator cutout switch to


PILOT
ALTERNATOR
STABILIZER
PRIMARY
AMPLIDYNE EXCITER
SERIES
FIELD
GENERATOR
FIELD
GENERATOR
A
B
C
CR3
CONTROL
FIELD
F_1
F_2
STABILIZER
SECONDARY
MANUAL
CONTROL
RHEOSTAT
COARSE
ADJUSTMENT
P1
FIXED RESISTANCE VOLTAGE DIVIDER
IN MANUAL CONTROL UNIT
MANUAL CONTROL RHEOSTAT
FINE ADJUSTMENT
BOOST CIRCUIT
BUCK CIRCUIT

27.34

Figure 4-8.—Manual control circuit.


EXCITER FIELD
PILOT ALTERNATOR
GENERATOR
SERIES FIELD
AMPLIDYNE
F2
F1
B
O
G
R
STABILIZER
AUTOMATIC CONTROL UNIT
CR3
CR2
PI
PI
MANUAL CONTROL UNIT
CRI
L
R
LI
CI
C
CT
P
LS
VOLTAGE-ADJUSTING UNIT
POTENTIAL CONTROL UNIT
A
B
C

111.29

Figure 4-9.—Schematic diagram of amplidyne voltage regulator installation.

MANUAL. Then turn the transfer switch to NORMAL after making certain that the generator circuit breaker is open. Start the prime mover and bring the generator up to speed. When the generator is up to speed, raise the generator voltage to approximately 450 volts. This is done by turning the handwheels of the manual control unit in the RAISE direction. Set the handle of the voltage-adjusting unit for 450 volts corresponding to no load. Place the automatic control unit in control of the a.c. generator voltage by turning the cutout switch from MANUAL to AUTOMATIC. Finally, adjust the generator voltage to 450 volts by turning the handle of the voltage-adjusting unit. The generator circuit breaker may then be closed.

If the generator is to be operated in parallel with a generator already connected to the bus, close the circuit breaker of the incoming generator only when the two voltages are in synchronism. As soon as the two generators are operating in parallel, readjust the governors of the prime movers until each unit takes its share of the kW load. Then equalize the power factors of the machines by means of the voltage-adjusting units. When the kW loads and power factors on the generators are equal, the current of each generator should then be equal.

If the system voltage is high after the power factors are balanced, slowly turn the voltage-adjusting units of both generators in the lower direction. Turn it until the system voltage is approximately 450 volts. If the system voltage is low, slowly turn the voltage-adjusting unit of both generators in the raise direction until the system voltage is approximately 450 volts.

To remove an alternator from the line, first remove the kW load by adjusting the governor while observing the wattmeter. When the kW load approaches zero, reduce reactive current load with the voltage-adjusting unit. Then trip the alternator's circuit breaker. After the generator is off the line, check to see that the manual control unit is set to the mark for 450 volts corresponding to no load. Then, shift the voltage regulator from AUTOMATIC to MANUAL. Next, turn the manual control in the lower direction.

Maintenance

Maintenance instructions for a specific rotary amplifier regulator given in the MRC and 3-M instructions take precedence over other procedures. However, the articles concerning care of rotating electrical machinery in chapter 310 of *Naval Ships' Technical Manual* (NSTM) should be observed in all cases where they do not conflict with the MRC, 3-M, or manufacturer's instructions.

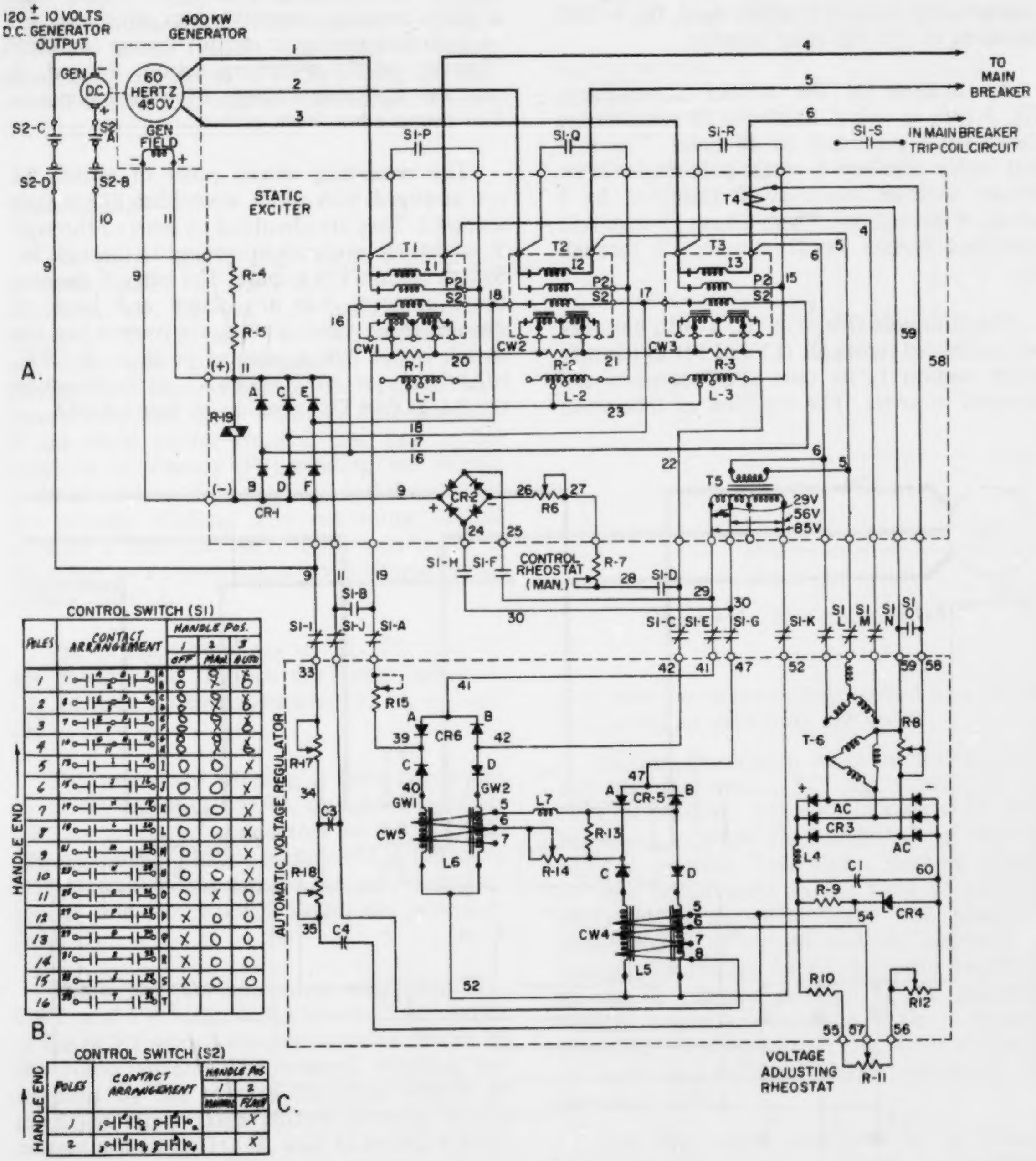
The amplidyne's short-circuiting brushes should be checked periodically. Improper brush contact may result in an excessively high amplidyne voltage output.

STATIC EXCITATION AND VOLTAGE REGULATION SYSTEM

The static excitation voltage regulator system furnishes a.c. generator field current by rectifying a part of the a.c. generator output. After the a.c. generator has built up some output with the aid of a field-flashing power source, an automatic voltage regulator controls the output of a static exciter to supply the necessary field current.

The schematic of a static excitation and magnetic amplifier-type voltage regulator system is illustrated in figure 4-10. The system provides field excitation in either manual or automatic control for the 400-kW, 450-volt, three-phase 60-hertz generator.

The control switch (S1) in figure 4-10B has three positions: OFF, MANUAL, and AUTOMATIC. The setting of this switch determines the type of operation to be used. The OFF position can be used to quickly de-energize the generator in case of an emergency. With the switch in the OFF position, four sets of contacts (sets P, Q, R, and S) are closed. Contacts P, Q, and R "short circuit" the potential winding of the three potential transformers. They are


120 ± 10 VOLTS D.C. GENERATOR OUTPUT
400 KW GENERATOR
GEN
D.C.
60 HERTZ 450V
GEN FIELD
S2-C
S2-D
S2-A
S2-B
STATIC EXCITER
TO MAIN BREAKER
IN MAIN BREAKER TRIP COIL CIRCUIT
S1-P
S1-Q
S1-R
S1-S
T1
T2
T3
T4
T5
29V
56V
85V
CW1
CW2
CW3
R-1
R-2
R-3
L-1
L-2
L-3
R-4
R-5
R-19
CR-1
CR2
R6
CONTROL RHEOSTAT (MAN.)
R-7
A.
CONTROL SWITCH (S1)
POLES
CONTACT ARRANGEMENT
HANDLE POS.
OFF
MAN.
AUTO
HANDLE END
B.
CONTROL SWITCH (S2)
MANUAL
FLAG
C.
AUTOMATIC VOLTAGE REGULATOR
R15
CR6
GW1
GW2
CW5
L6
L7
R-13
R-14
R-17
R-18
C3
C4
CR-5
CW4
L5
T-6
R8
CR3
AC
L4
C1
R-9
CR4
R10
R12
VOLTAGE ADJUSTING RHEOSTAT
R-11

111.30

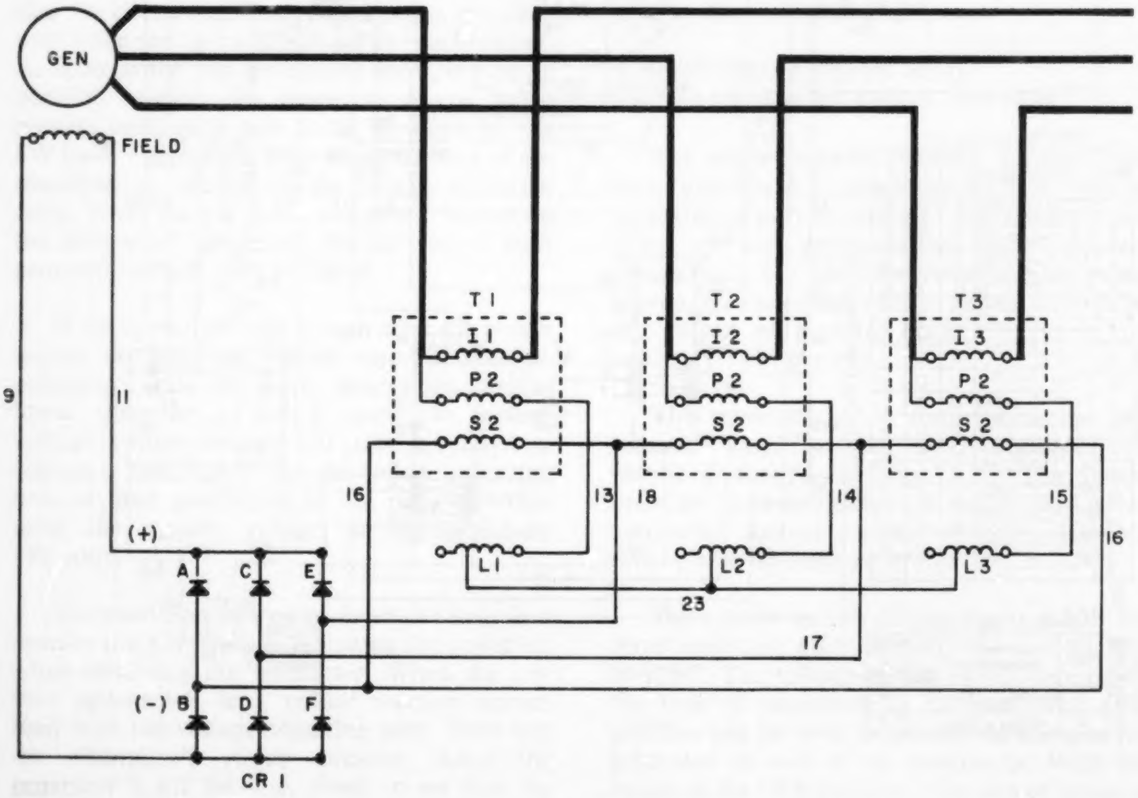
Figure 4-10.—Elementary diagram of static excitation voltage regulator system.

identified as T1, T2, and T3 in figure 4-10A. They remove rectified current from the exciter. Concurrently, contact S (upper right, fig. 4-10A) functions to trip the main breaker.

An analysis of the contact arrangement (fig. 4-10B) in switch S1 shows 32 contacts are placed (four per pole) on 16 poles. The first four poles produce 8 single-pole-single-throw contact switches (each SPST identified by 8 letters, A through H). These 8 have 12 terminals (identified further by 12 numbers, 1 through 12).

The fifth pole (No. 5 in fig. 4-10B) has only two numbered terminals (13 and 14) to identify switch section I. Its two SPST contacts are arranged in series. The function of this series arrangement is twofold. First, it provides two contacts that can open fast and wide. This quickly prevents excessive arcs produced (in an inductive-reactance circuit) during the OFF "break" of the switching action. Second, it provides optimum cooling of heated contacts that become hot from arcing.

The remaining eleven poles of switch S1 are arranged with series assemblies like switch section I. They are identified by letters J through T, with their terminals numbered 15 through 36. Switch section T is a spare. The letter X denotes those contacts that are closed and letter O denotes those contacts that are open when the switch is put into a selected position of OFF, MANUAL, or AUTOMATIC. S1 is shown in the AUTOMATIC position in figure 4-10A.



111.31

Figure 4-11.—Static exciter.

Switch S2 is an assembly of 18 contacts (fig. 4-10C). They are connected in series, operate simultaneously, and function as a single ON-OFF device. Again, the function (using many contacts) serves to break a long arc into several smaller arcs and produce longer life for the heat-dissipating contacts.

Static Exciter

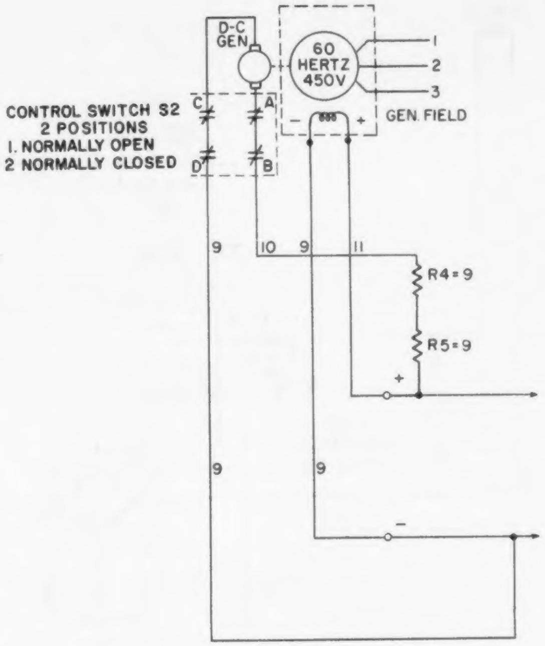
The static exciter (fig. 4-11) consists of a three-phase rectifier, CR1; three linear inductors, L1, L2, and L3; and three transformers, T1, T2, and T3. The transformers are alike and interchangeable. Each transformer has four windings, but figure 4-11 shows only the three windings that perform in the basic exciter circuits. The first is the potential or primary (P2) winding, the second is the secondary (S-2) winding, and the third is the current winding. The remaining control winding is discussed later. Each transformer is identified as a saturable current potential transformer (SCPT).

The primary windings of T1, T2, and T3 are Y-connected through the linear inductors L1, L2, and L3 by conductors 13, 14, 15, and 23.

The secondary winding is delta connected to diodes (A, B, C, D, E, and F) of rectifier CR1 by means of conductors 16, 17, and 18. These elements include a three-phase full-wave bridge rectifier that delivers d.c. to conductors No. 11 and No. 9 which supply the generator field.

The current in the control windings CW1, CW2, and CW3 (fig. 4-10A) controls the output of the SCPT secondaries and thus the output of the static exciter. The control windings are supplied by the voltage regulator output as discussed later. Load current flowing in the current windings (I1, I2, and I3 in fig. 4-10A) compensates for changes in the generator load.

FIELD-FLASHING CIRCUIT.—The static exciter cannot supply field current until some a.c. voltage has built up on the 400-kW generator.



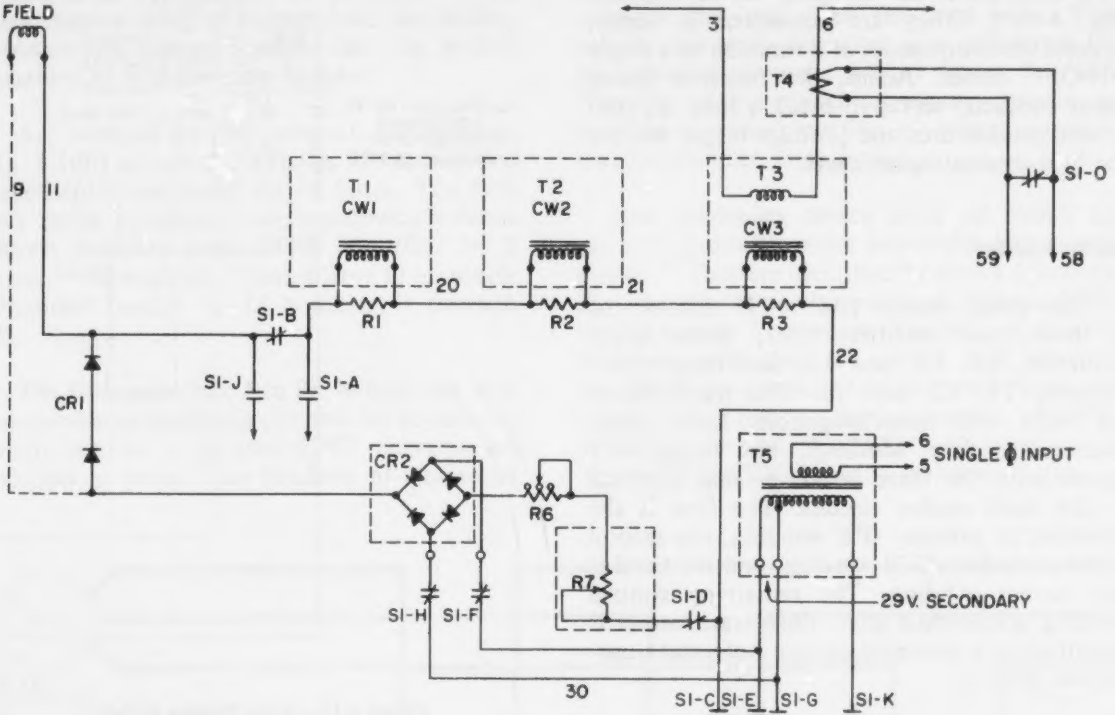
111.32

Figure 4-12.—Field-flashing circuit.

D.c. power is temporarily provided by a 50-kW d.c. generator delivering 120 volts.

To start the system, move the spring-return field-flashing switch, S-2 (fig. 4-10C), to the FLASH position. The control switch, S1, may be placed in either the MANUAL or AUTOMATIC position. This allows flashing current to flow temporarily to the field of the a.c. generator, as shown in figure 4-12, when the prime mover is started and the generator is brought up toward its rated speed. Switch S2 should be released as soon as the generator voltage begins to build up. This is because thereafter the static exciter (fig. 4-11) is capable of continuing the d.c. voltage required by the generator field.

The field does not have to be flashed every time the system is placed in operation. It is usually necessary to flash the field only after a generator malfunction or when the generator is idle for long periods of time, such as overhaul periods.



111.33

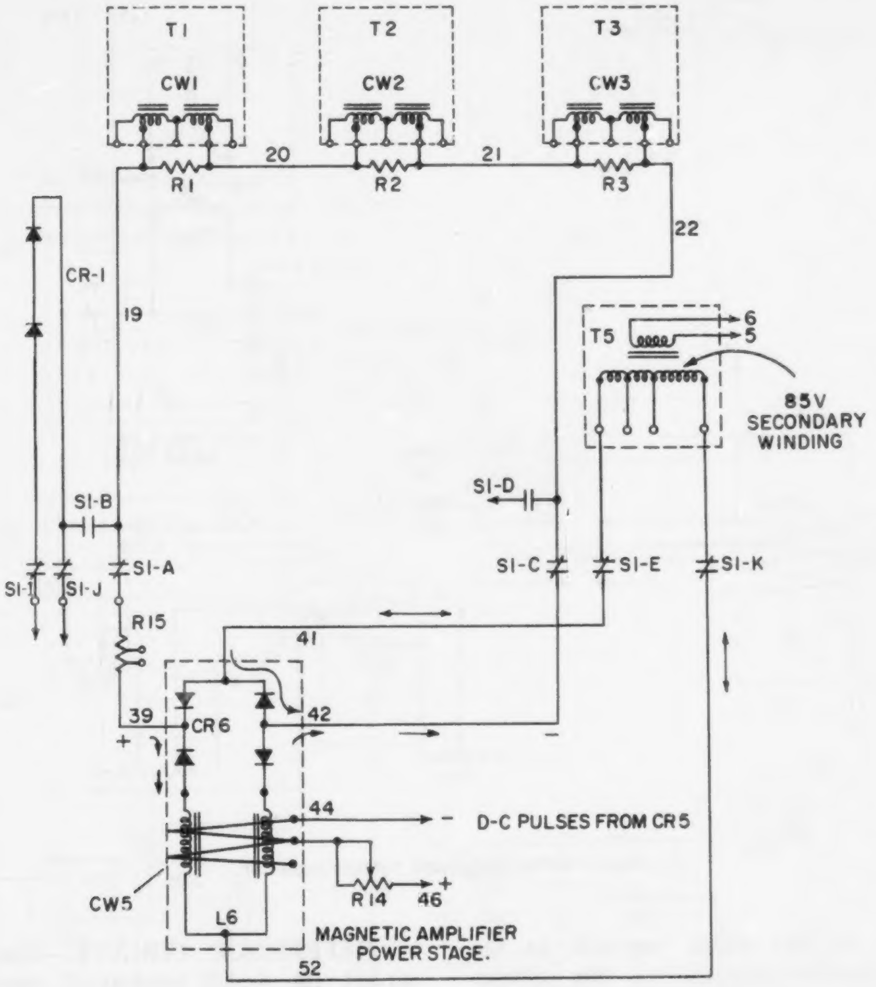
Figure 4-13.—Manual voltage control circuits.

MANUAL VOLTAGE CONTROL CIRCUIT.—With switch S1 (fig. 4-13) in the manual position, contacts F and H are closed, connecting the 29-volt secondary of transformer T5 to the bridge rectifier CR2. The resulting d.c. leaves CR2 from its negative terminal, flows by way of resistor R6, manual control R7, and closed switch S1-D to conductor No. 22. This direct current flow continues through the series arrangement of each SCPT control winding. It combines temporarily with the flow of the generator's d.c. field passing from + to − of rectifier CR1. It terminates at the positive terminal of rectifier CR2.

Five switch sections of S1 are closed to establish manual control for the exciter's output, namely, B, D, F, H, and O. Switch S1-0 short circuits the output of transformer T4. This eliminates a drooping characteristic which is not now required. Manual operation is achieved by regulating resistor R7. This functions to vary the saturation of the cores of T1, T2, and T3. Varying the amount of direct current alters the core saturation. Those variations will change the voltage value that is induced from each primary into its associated secondary winding, shown in figure 4-11.

Automatic Voltage Regulator

The static exciter alone (fig. 4-11) will not maintain the different amounts of field current required to maintain a constant value of a.c. voltage at the generator terminals during various load changes. Therefore, a voltage regulator is needed to hold the generator voltage constant. The automatic regulator controls the exciter output by regulating precisely the flow of d.c. in


T1
T2
T3
CW1
CW2
CW3
20
21
R1
R2
R3
22
CR-1
19
T5
6
5
85V
SECONDARY
WINDING
S1-D
S1-B
S1-A
S1-I
S1-J
S1-C
S1-E
S1-K
R15
41
39
CR6
42
+
−
44
D-C PULSES FROM CR5
CW5
R14
46
L6
MAGNETIC AMPLIFIER
POWER STAGE.
52

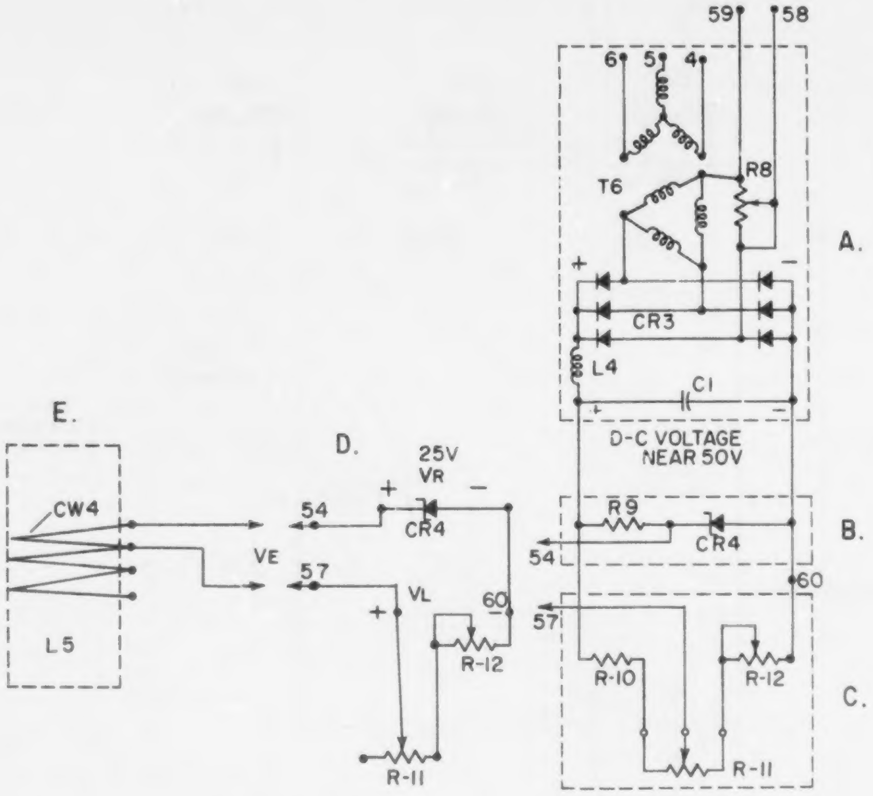
111.34

Figure 4-14.—Final-stage magnetic amplifier.

the control winding of each SCPT (T1, T2, and T3 in fig. 4-14). Here the initial a.c. is provided by the 85-volt secondary of transformer T5. This feeds rectifier CR6 to provide the d.c. source at terminals 39 and 42. The flow of d.c. is precisely controlled by the ohmic reactance values of each coil of L6. The controlled reactance depends on the state of magnetic saturation produced by another regulated d.c. flow from rectifier CR5 (fig. 4-10A).

The control of this regulated output of rectifier CR5 originates with sampling the average of the three line voltages by the sensing circuit in figure 4-15A. This voltage is processed further in the reference and comparison circuits (fig. 4-15B and C) for amplification in the preamplifier of figure 4-16.

SENSING CIRCUIT.—To obtain the best regulation during unbalanced load conditions in the three phases, the regulator uses the sensing



111.35

Figure 4-15.—Automatic voltage regulator.

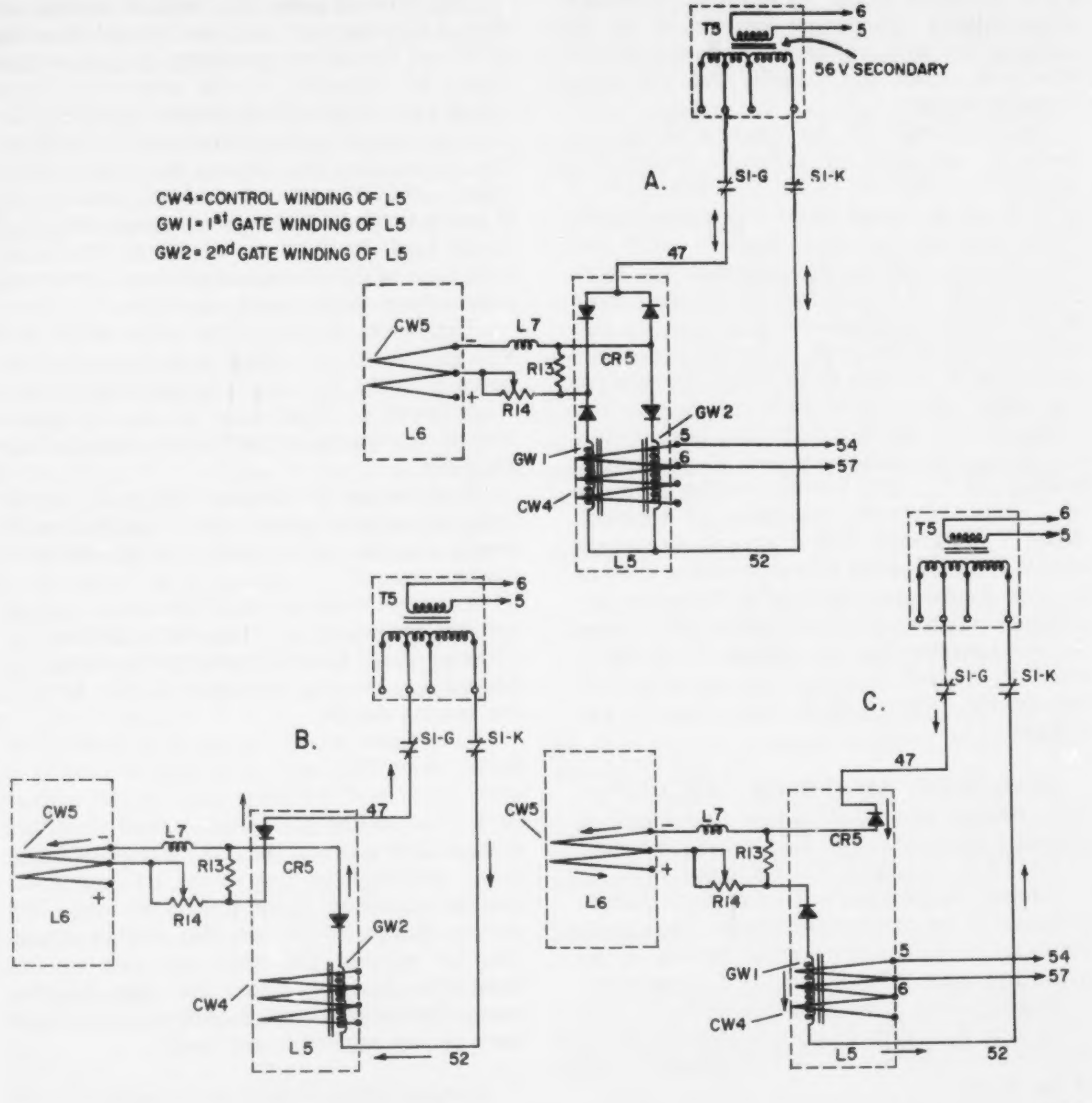
circuit (fig. 4-15A) which responds to the average of the three values of a.c. line voltages (terminals 4, 5, and 6).

Transformer T6 reduces the line voltage of each phase to a convenient value. Rectifier CR3 converts the three-phase a.c. to d.c. voltage. If an unbalanced condition causes the three line voltages to become unequal, the d.c. across the rectifier will have considerable (third harmonic) ripple. However, the combined filter actions of inductor L4 and capacitor C1 will remove the ripple and produce d.c. across C1 (near 50 volts). This is always in proportion to the average of the three line voltages.

Resistor R8 is used for reactive droop compensation and will be discussed later.

REFERENCE CIRCUIT.—The reference circuit (fig. 4-15B) consists of resistor R9 and zener diode. The function of CR4 is to supply a nearly constant (25 volt) reference voltage to the comparison circuit. Dropping resistor R9 limits the current through CR4 to a safe value. If the voltage (near 50 volts) across R9 and CR4 increases, the current increases in both items. The voltage increases only across R9, leaving the voltage across CR4 at its original voltage value (25 volts). CR4 consists of four zener diodes with each diode operating in the breakdown region and having nearly a constant 6.2 voltage drop across each unit.

COMPARISON CIRCUIT.—The comparison circuit consists of the reference circuit


T5
6
5
56 V SECONDARY
A.
SI-G
SI-K
CW4 = CONTROL WINDING OF L5
GW1 = 1st GATE WINDING OF L5
GW2 = 2nd GATE WINDING OF L5
47
CW5
L7
R13
CR5
R14
L6
GW2
GW1
CW4
5
6
54
57
L5
52
B.
C.

111.36

Figure 4-16.—First-stage magnetic amplifier.

(fig. 4-15B), combined with resistors R10, R11, and R12 (fig. 4-15C). Its function is to compare the "average line voltage" to the reference voltage. It also acts on the first-stage magnetic amplifier to correct any transients.

ERROR VOLTAGE.—Three sets of tests are made with a d.c. voltmeter at the 3 terminals (numbered 54, 57, and 60) in figure 4-15C. These tests reveal several facts that explain the ERROR VOLTAGE (V_E) produced across terminals No. 54 and No. 57 (fig. 4-15D). Connect a d.c. voltmeter to the V_E terminal. Disregard meter-polarity connections since some of the performance tests will cause the meter to read downscale when the polarity (of the error voltage) reverses.

Initial changes in the amount of V_E are made by adjusting the slider on VOLTAGE ADJUSTING RHEOSTAT R11. A slider position of R11 will be found where V_E registers zero. Then reposition the meter leads to verify that the reference voltage V_R (terminal No. 60 is negative; No. 54 is positive) will always remain at 25 volts regardless of generator output. Relocate the meter leads to measure V_L and verify that it has the same value (25 volts) as V_R, when V_E is zero. This will be for this measurement only. If resistor R11 is readjusted to produce, for example, either a 27- or a 23-volt reading for V_L, then V_E has a numerical value of 2 volts. However, polarities are reversed. When V_L is greater than V_R, a direct current will flow in the control primary winding CW4 of the first-stage magnetic amplifier. The automatic voltage regulator will reduce the exciter voltage, thereby lowering the line voltage. Conversely, when V_L is less than V_R, the regulator will increase the exciter voltage. This raises the line voltage.

MAGNETIC AMPLIFIER CIRCUITS.—The essential parts that include two stages of magnetic amplifiers (figs. 4-14 and 4-16) consist of L5, CR5, R13, R14, L6, CR6, and R15.

Changes in generator voltage produce changes in current in the comparison circuit. These are in the order of milliamperes while flowing in the control winding, CW4 (fig. 4-16). It is necessary to amplify these initial small currents so their effect is in the order of several amperes in the final control windings of CW1, CW2, and CW3 of the SCPTs.

Two magnetic-amplifier gates (GW1 and GW2) function automatically and alternately in figure 4-16 to regulate the flow of a.c. delivered by the 56-volt secondary of transformer T5. The automatic regulation is achieved by saturating and desaturating the flux in the cores of GW1 and GW2. The degree of flux at any moment in each core is determined by the previously described conditions of d.c. flow in the control winding, CW4.

The flow of gated a.c., and its conversion into d.c. pulses in another control winding (CW5 of the power amplifier, L6), is readily traced by inspection of the arrows in figure 4-16B and 4-16C. These arrows alongside the conductors and rectifier elements are in the direction of electron flow during one half cycle in figure 4-16C. The control winding current can be changed until the full supply voltage is applied to the load. In this way, a control winding in each stage of the several saturated cores controls output from the magnetic amplifier.

The series resistors R14 (fig. 4-16) and R15 (fig. 4-14) are adjusted so each amplifier operates in the center of its saturation curve.

Inductor L7 (fig. 4-16) is used to assure smooth continuous control of the second-stage amplifier.

Transformer T5 is used to supply d.c. power to the two magnetic amplifiers. It is also used to supply control current when it is operating in manual control.

A control winding would function to change its flux by means of either "d.c. pulses" or "filtered d.c." Control winding CW4 employs filtered d.c. by using capacitor C1 (fig. 4-15) in the sensing circuit.

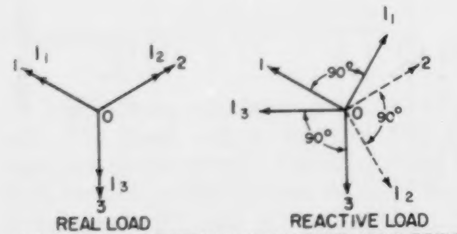
If, in figure 4-16B, the supply voltage (from transformer T5) is applied to the gate winding in series with its CW5 load, most of the voltage drop is across the gate winding (and very little voltage drop is across the CW5 control-winding load), provided the flux in the L5 core never reaches saturation. If the control-winding CW4 current changes so the core flux reaches saturation for part of the cycle, the gate-winding inductance drops to a very low value for that part of the cycle. A portion of the supply voltage wave is then applied to the load.

STABILIZING CIRCUIT.—In any closed-loop regulating system that contains several time constants and has high gain, sustained oscillations would be produced. Undesired oscillation is sometimes called HUNTING. To prevent hunting, a stabilizing filter circuit (resistor R17 and capacitor C3 in figure 4-10A) is used to remove the normal ripple from the exciter output voltage. Another network (resistor R18 and capacitor C4) stabilizes the exciter output voltage.

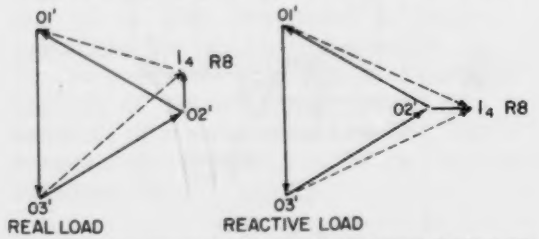
Nonlinear resistor, R19, is used to suppress abnormally high transient voltage that may appear across the field rectifier, CR1.

REACTIVE DROOP COMPENSATION CIRCUIT.—Current transformer T4 and resistor R8 are used to obtain the generator-drooping characteristic. The vector diagrams for this circuit are shown in figure 4-17(A) and (B). Figure 4-17(A) shows the line voltages and currents for real and reactive loads. Figure 4-17(B) shows the voltages on the secondary of the transformer T6, along with the IR (voltage) drop (produced across resistor R8 because of its "current from the secondary, T4," called I_4). For an in phase, real load, this "I_4 R8" voltage drop shortens vector 01′ but lengthens vector 02′ (dashed lines). The average of the three vectors remains essentially constant. However, for a reactive load the "I_4 R8" voltage drop lengthens vectors 01′ and 02′ (dashed lines) and increases the average of the three vectors.

The regulator senses this higher voltage and reduces the generator voltage. It does this by giving the generator a drooping characteristic for reactive loads.



(A) VECTOR DIAGRAMS OF LINE VOLTAGES AND CURRENTS.



(B) VECTOR DIAGRAMS OF VOLTAGES AND CURRENTS FOR T6 & T4

111.37

Figure 4-17.—Vector diagrams of reactive droop circuit.

Since the average of the three vectors 01′, 02′, and 03′ did not change for a real load, the generator output should remain essentially constant.

The amount of reactive droop can be increased by increasing the resistance of resistor R8. Ensure the resistance is 2 ohms or more.

Manual Operation

To start the equipment, set the manual control rheostat R7 for minimum volts (fully counterclockwise). Set the control switch S1 on MANUAL. Next hold the FLASHING SWITCH S2 in the FLASH position until the generator starts to build up. Then adjust the manual control rheostat R7 to obtain the proper generator voltage. The system is now operating in MANUAL.

Automatic Operation

To operate the system in AUTOMATIC, turn the control switch S1 to the AUTO position. Adjust the voltage-regulating rheostat R11 to obtain the proper voltage.

The control switch S1 should never be left in an intermediate position between MANUAL and AUTOMATIC.

The control switch S1 has an emergency shutdown feature when placed in its OFF position. This can be used to quickly de-energize the generator in case of an emergency.

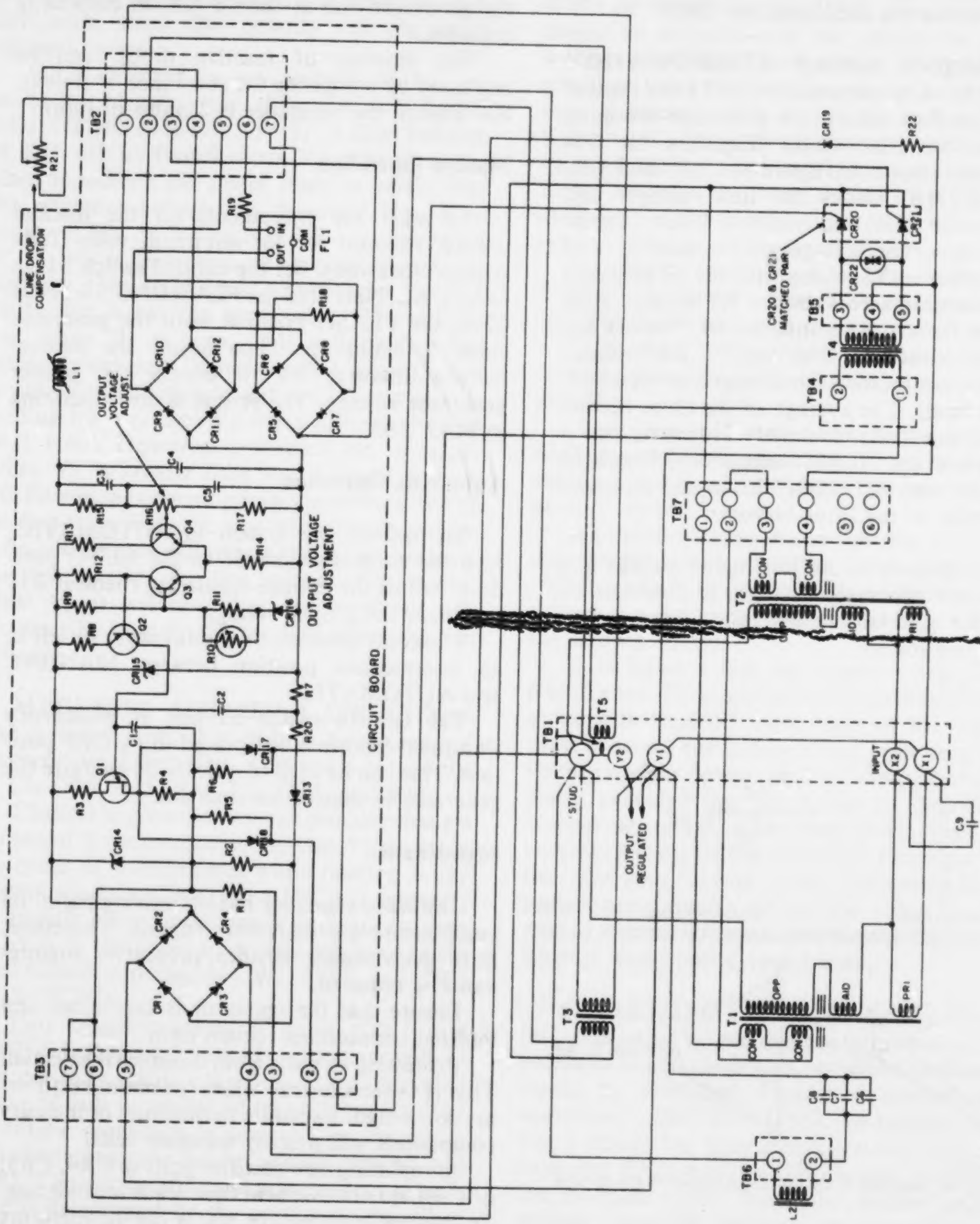
Maintenance

The static regulator has no moving parts. Its components are extremely rugged. Therefore, little maintenance besides preventive maintenance is required.

Ensure that the regulator is kept clean and internal connections remain tight.

Protecting all parts from moisture is essential. This is especially true where selenium rectifiers are concerned. Exposure to moisture or mercury compounds will destroy selenium cells.

In replacing new rectifier units in CR4, CR5, or CR6, do not overheat their leads in soldering. To prevent overheating, use a low-temperature solder (rosin core). Attach a small heat sink such as an alligator clip or long-nosed pliers between


TB2
R21
LINE DROP COMPENSATION
L1
R19
OUT
IN
COM
FL1
R18
OUTPUT VOLTAGE ADJUST
CR10
CR12
CR9
CR11
CR6
CR8
CR5
CR7
C3
C4
C5
R13
R15
R16
Q4
R17
R14
OUTPUT VOLTAGE ADJUSTMENT
R12
Q3
R9
R11
R8
Q2
R10
CR16
CR15
R7
C2
R20
CIRCUIT BOARD
C1
CR17
Q1
R3
R4
R6
R5
CR13
CR14
R2
CR18
R1
CR2
CR4
CR1
CR3
TB3
TB1
T5
STUD
Y2
Y1
OUTPUT REGULATED
INPUT
X2
X1
C9
TB7
CON
T2
OPP
AID
PRI
T3
T1
C8
C7
C6
TB6
L2
TB4
T4
TB5
CR20 & CR21 MATCHED PAIR
CR22
CR20
CR21
CR19
R22

111.102(111C)

Figure 4-18.—SPR-400 line voltage regulator.

the rectifier and the attached lead where the soldering occurs. This will prevent damaging heat from reaching the rectifier cell.

If it is necessary to apply a high-potential test to the exciter or generator with a meggar, short out all rectifiers with clip leads. High-potential tests are discussed in chapter 300, *Naval Ships' Technical Manual.*

SPR-400 LINE VOLTAGE REGULATOR

The SPR-400 line voltage regulator is a general-purpose, automatically controlled a.c. line regulator. It is designed for naval ships. It ensures precision voltage regulation for line, load, frequency, and power factor variations in single or three-phase (delta or wye connection) circuits. There are several designs of line voltage regulators available. The operation described in the next section will cover a typical design. The line voltage regulator is designed around the use of the silicon controlled rectifier (SCR). The SCR acts as a switch when a control voltage is applied to it.

Operation

The voltage regulator is installed in series with the load which requires the precisely regulated power supply. The unit shown in figure 4-18 controls a single-phase circuit. The input is at terminals X1 and X2 on terminal board 1 (TB1). Regulated output is from terminals Y1 and Y2 on TB1. Regulation is achieved by controlling the two autotransformers, T1 and T2. An acceptable waveform is ensured where one side of the transformer output goes to a harmonic filter via terminal 1 on TB1. The filter consists of the inductor L2 on TB6 and the parallel capacitors C6, C7, and C8.

Voltage from terminals Y1 and 1 on TB1 drives the rectifier bridge consisting of CR1, CR2, CR3, and CR4 on the circuit board. This bridge provides d.c. power for the solid state components on the board.

The input is applied to Y1 and 1 through autotransformers T1 and T2. Transformers T3 senses the line voltage changes and varies the conduction of transistors Q4 and Q3, through the rectifier bridge, by varing the voltage drop across R16. Q2 is controlled by differential amplifiers Q4 and Q3. Q2, in turn controls the charging rate of capacitor C1. C1 raises the emitter-base 1 potential of Q1. The firing of Q1 sends gate pulses to SCRs CR20 and CR21 through terminals 1 and 2 of TB3. When the SCRs are gated, autotransformer T1 and T2 control windings receive d.c. current which controls the output of the autotransformers.

For example, when line voltage increases, Q4 conducts more and Q3 conducts less. Q2 in turn conducts less. C1 will charge more slowly and Q1 will fire later in each half cycle. The SCRs will also be gated later in each half cycle. Autotransformer control windings receive d.c. current later in each half cycle and the potential at Y1 and 1 will decrease.

If line potential at Y1 and 1 decreases too far, Q4 will conduct less and Q3 more. Q2 will now conduct more and charge C1 faster. Q1 will now fire earlier in each half cycle and gate the SCRs earlier. Control windings in the autotransformer receive d.c. current earlier, decreasing autotransformer impedance and allowing line potential to increase.

Remember, the application of input power (across terminals X1 and X2 of TB1, fig. 4-18) energizes the two parallel operated autotransformers. The input voltage is stepped up by an aiding winding (AID). This is wound directly over the primary winding (PRI). The voltage is then reduced to nominal output by an opposing winding (OPP). The magnitude of induced voltage in the opposing winding is varied by the level of d.c. in the control windings (CON) from the SCRs. The opposing and the control windings are separated from the primary and the aiding windings by a magnetic shunt. Increasing the d.c. in the control windings forces the magnetic flux through the shunt. This decreases the opposing voltage, and thus increases the output.

Power to the SCRs is taken from stepdown transformer T4. The primary of T4 is connected across the regulator output. Diode CR19 provides a discharge path via terminals 6 and 7 of TB3 for the control windings of T1 and T2 when the SCRs are shut off. The SCRs are protected from excessive peak inverse voltage by silicone diode CR22. The silicone diode acts as an insulator during normal operation. When an excessive voltage is applied to it, it shorts. This protects the SCRs. When the voltage returns to normal, the silicone diode will again be an insulator.

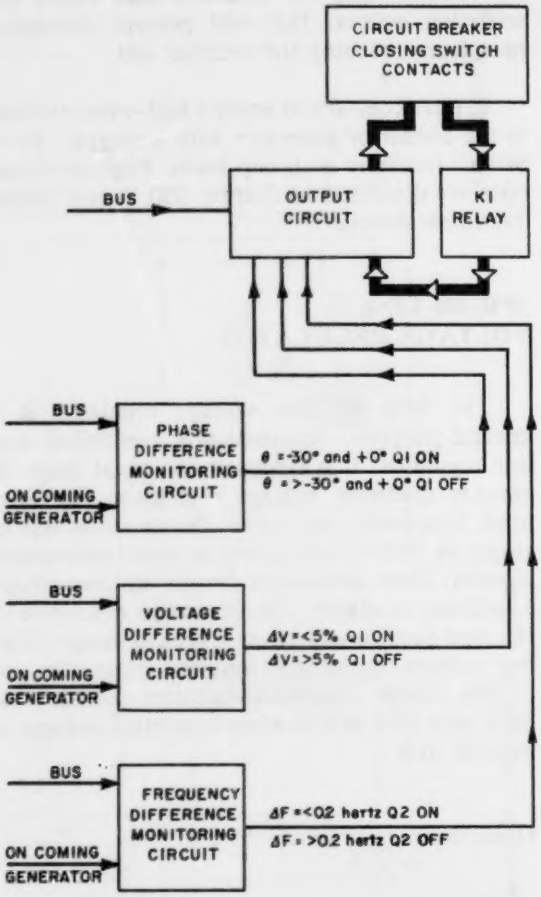
An additional output voltage compensation is provided for cable loss when the stud of terminal Y2 passes through current transformer T5. It induces a signal in T5 proportional to the load current. Adjustment of potentiometer R21 provides compensation in this circuit. The potentiometer setting compensates for the resistance in cables from the regulator to the load. Once set, it does not have to be changed unless the cables (not the load) are changed.

Maintenance

Normally, little preventive maintenance, other than that described on the maintenance requirement cards, is required. This is because the components are stable and nonwearing with no moving parts (other than two potentiometers). Make frequent inspections for dust, dirt, and moisture accumulation. Clean the equipment as necessary.

SYNCHRONIZING MONITOR

The synchronizing monitor (fig. 4-19) monitors the phase angle, voltage, and frequency relationship between the 450-volt, 60-hertz generator and an energized bus. Circuits within this panel energize a relay when the phase angle (0) is between −30° and 0°, the voltage difference (ΔV) is less than 5 percent, or the frequency drift (ΔF) between an oncoming generator and an energized bus is less than 0.2 hertz.

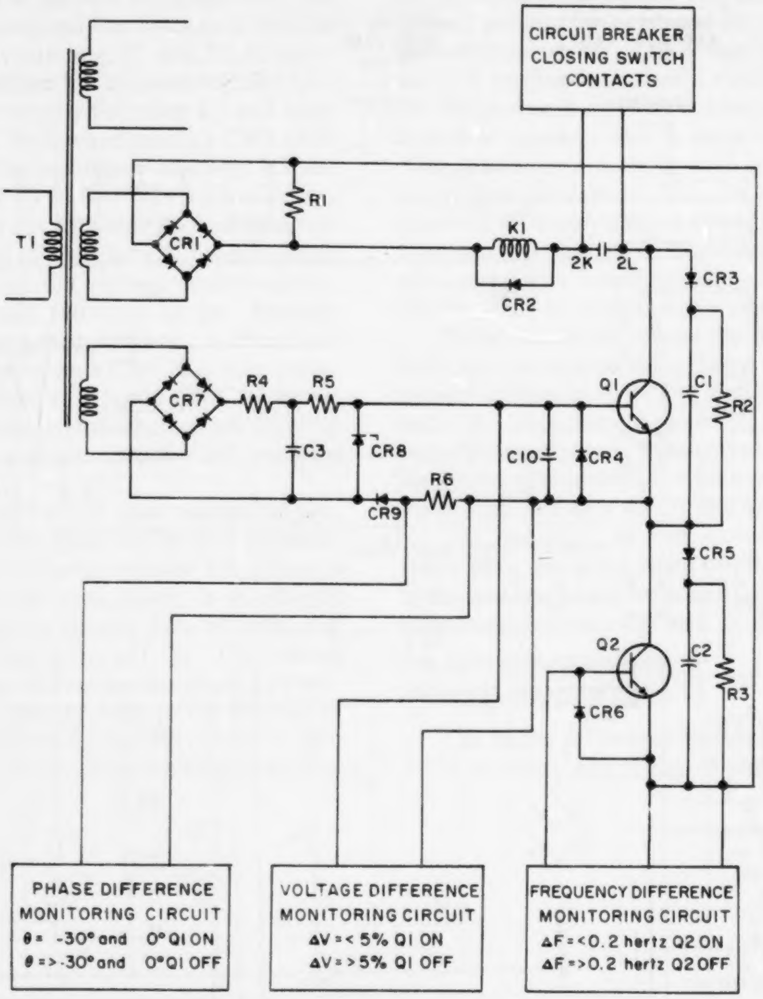

CIRCUIT BREAKER CLOSING SWITCH CONTACTS
BUS
OUTPUT CIRCUIT
KI RELAY
BUS
PHASE DIFFERENCE MONITORING CIRCUIT
ON COMING GENERATOR
θ = -30° and +0° QI ON
θ = >-30° and +0° QI OFF
BUS
VOLTAGE DIFFERENCE MONITORING CIRCUIT
ON COMING GENERATOR
ΔV = <5% QI ON
ΔV = >5% QI OFF
BUS
FREQUENCY DIFFERENCE MONITORING CIRCUIT
ON COMING GENERATOR
ΔF = <O2 hertz Q2 ON
ΔF = >0.2 hertz Q2 OFF

111.105

Figure 4-19.—Block diagram of synchronizing monitor.

The synchronizing monitor does not automatically parallel two generators when it is connected to the system. The generators must be paralleled manually. This is independent of whether or not the synchronizing monitor is connected to the circuit. The function of the synchronizing monitor is to prevent the manual paralleling of two generators when the phase angle, voltage difference, and frequency difference of the two generators are not within safe limits.

The synchronizing monitor consists of four main circuits: the output circuit, the phase difference monitor circuit, the voltage difference


CIRCUIT BREAKER
CLOSING SWITCH
CONTACTS
T1
R1
CR1
K1
2K
2L
CR2
CR3
CR7
R4
R5
Q1
C1
R2
C3
CR8
C10
CR4
R6
CR9
CR5
Q2
C2
R3
CR6
PHASE DIFFERENCE
MONITORING CIRCUIT
θ = -30° and 0° Q1 ON
θ => -30° and 0° Q1 OFF
VOLTAGE DIFFERENCE
MONITORING CIRCUIT
ΔV =< 5% Q1 ON
ΔV => 5% Q1 OFF
FREQUENCY DIFFERENCE
MONITORING CIRCUIT
ΔF =< 0.2 hertz Q2 ON
ΔF => 0.2 hertz Q2 OFF

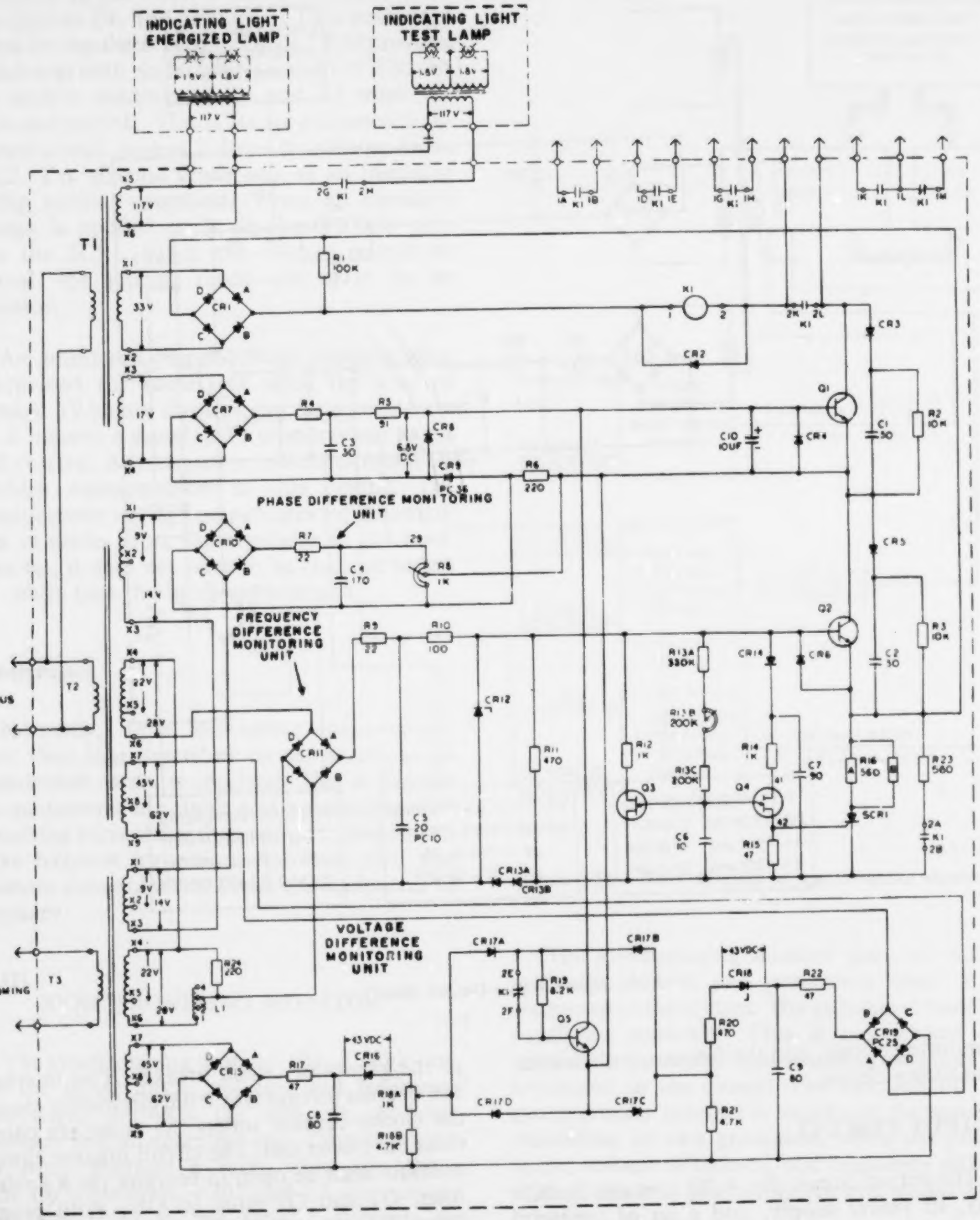
111.106

Figure 4-20.—Output circuit.

monitoring circuit, and the frequency difference monitoring circuit.

OUTPUT CIRCUIT

The output circuit (fig. 4-20) contains the K1 relay, its power supply, and a set of contacts (circuit breaker closing switch contacts) in series with transistors Q1 and Q2. The K1 relay provides an electrical interlock through the closing circuit of the generator circuit breaker. This interlock will prevent an operator from electrically closing the circuit breaker unless the necessary conditions have been met. The circuit breaker closing contacts must be open to energize the K1 relay. Also, Q1 and Q2 must be ON. With proper "circuit breaker line up," the first condition is met. The monitoring circuits must provide the current signals to Q1 and Q2 to turn them on.


INDICATING LIGHT
ENERGIZED LAMP
INDICATING LIGHT
TEST LAMP
117V
T1
T2
T3
BUS
ONCOMING
33V
17V
9V
14V
22V
28V
45V
62V
CR1
CR7
CR10
CR11
CR15
CR19
K1
Q1
Q2
Q3
Q4
Q5
SCR1
PHASE DIFFERENCE MONITORING UNIT
FREQUENCY DIFFERENCE MONITORING UNIT
VOLTAGE DIFFERENCE MONITORING UNIT
R1 100K
R2 10K
R3 10K
R6 220
R7 22
R8 1K
R9 22
R10 100
R11 470
R13A 330K
R13B 200K
R13C 300K
R16 560
R23 560
R19 8.2K
R20 470
R21 4.7K
R22 47
R17 47
R18A 1K
R18B 4.7K
R24 220
C1 50
C2 50
C3 30
C4 170
C5 20
C7 90
C8 80
C9 80
C10 10UF
43VDC
6.8V DC
L1

111.107

Figure 4-21.—Synchronizing monitor.

Looking at the schematic in figure 4-21, you can see that the energized bus voltage is stepped down by secondary winding X1 and X2 of transformer T1. It is rectified by full-wave rectifier CR1 to form the power supply for relay K1 and transistors Q1 and Q2. Full-wave rectifier CR7 rectifies the output of the secondary windings X3 and X4 of transformer T1 to form the reference bias supply to transistor Q1. Resistor R4 and capacitor C3 filter the output of rectifier CR7. Zener diode CR8, because of its flat voltage characteristic, maintains a constant reference to Q1. Resistor R5 is a voltage-dropping resistor. It limits the voltage across Zener diode CR8 to a safe value. If the voltage applied to R5 and CR8 increases, the increased voltage is absorbed as an IR drop across R5. The voltage across CR8 remains constant.

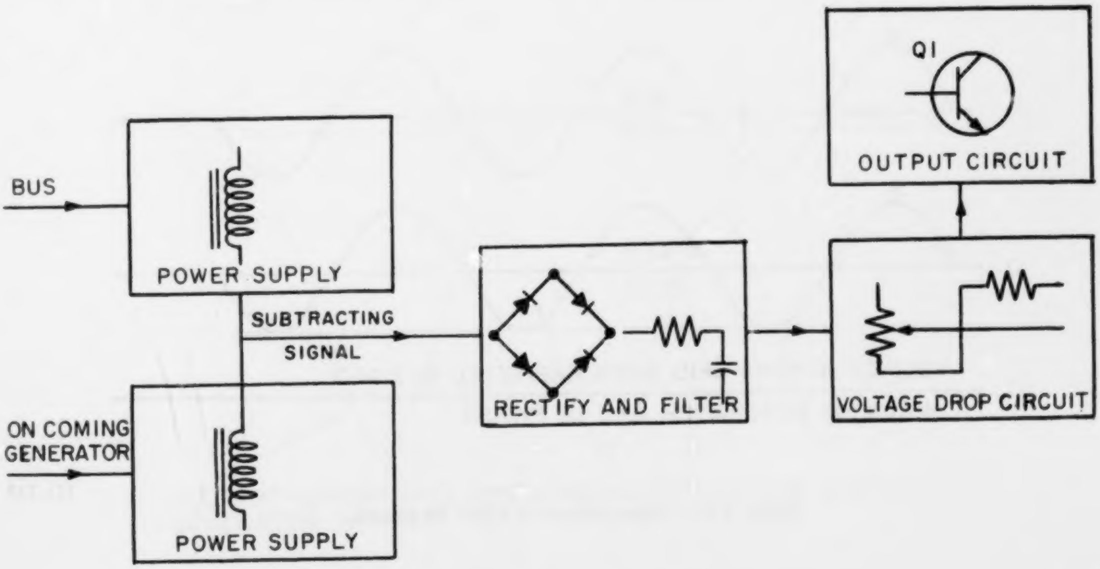
Two circuits affect the bias voltage of Q1. The first circuit is the phase difference monitoring circuit, which includes resistor R6. When a voltage of sufficient magnitude is developed across R6, the base to emitter bias of transistor Q1 is reversed. This turns off Q1. The second circuit is the voltage difference monitoring circuit. It is connected across the base to the emitter of transistor Q1. When transistor Q5 conducts, this circuit disables Q1 by shorting the base to emitter of Q1. This removes the bias reference supply. Q1 can conduct or be biased on only when these two circuits are off. The action by the Q1 transistor is similar to that of a switch. A transistor can be used so it acts like contacts that are either closed or opened. This is done by using a large enough base current signal that can drive the transistor into saturation. This, in turn, acts like a short circuit (equivalent to closed contacts). If the base current signal is weakened, reversed, or eliminated, the transistor then acts as an open circuit. This is equivalent to open contacts.

Transistor Q2 completes the circuit to energize relay K1. Transistor Q2 is biased on from the frequency difference monitor. Rectifiers CR2, CR3, and CR5, capacitors C1 and C2, and resistors R2 and R3 damp-out voltage spikes on Q1 and Q2. Rectifiers CR4 and CR6 limit emitter to base (reverse bias) voltages on Q1 and Q2 to low values.

The operation of this circuit is as follows: Relay K1 is energized when transistors Q1 and Q2 are biased on, and circuit breaker switch contacts connected between 2K and 2L are closed.

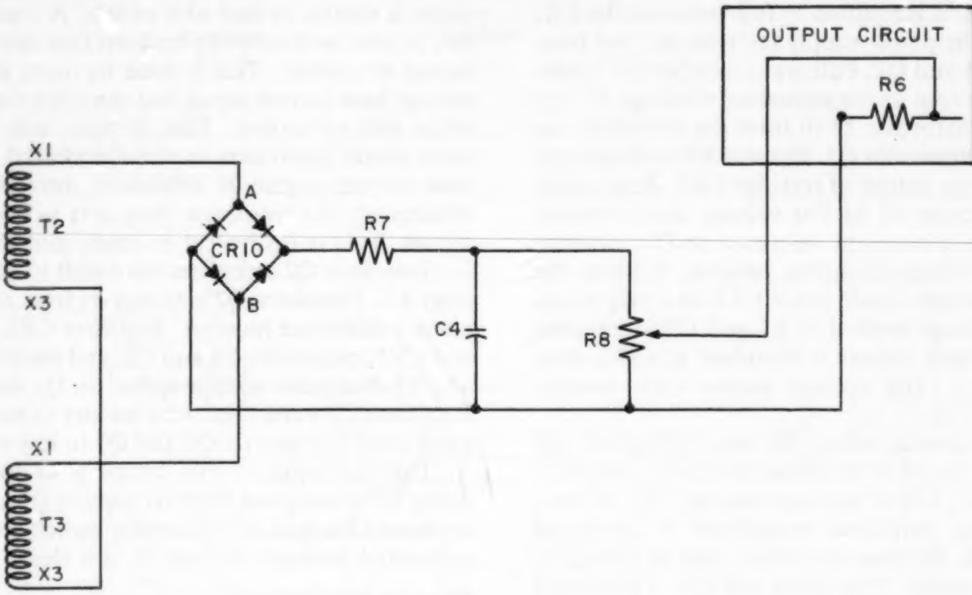
PHASE DIFFERENCE MONITORING CIRCUIT

The phase difference monitoring circuit (fig. 4-22) prevents energizing of the K1 relay if the



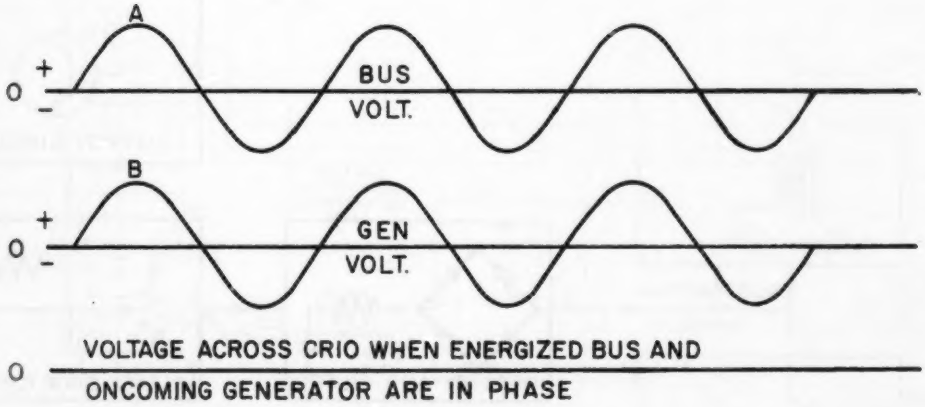
111.108

Figure 4-22.—Block diagram of phase difference monitoring circuit.


OUTPUT CIRCUIT
R6
X1
T2
A
CR10
R7
B
X3
C4
R8
X1
T3
X3

111.109

Figure 4-23.—Schematic diagram of phase difference monitoring circuit.



111.110

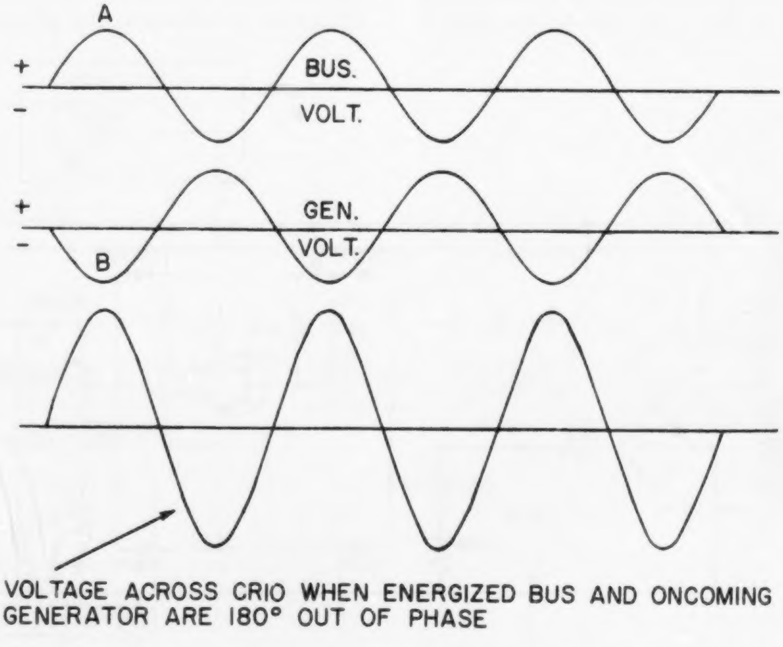
Figure 4-24.—Input voltage to CR10 (in phase).

phase difference between the bus and the oncoming generator is more than −30° and 0°. It does this by reducing and comparing both input voltages (bus and incoming generator), rectifying and filtering both input voltages, and using its output to control transistor Q1.

Look at the schematic in figure 4-23. The secondary winding X1 and X3 of T2 and X1 and X3 of T3 are connected so the output voltages of T2 and T3 subtract from each other. For instance, assume that the voltages are in phase, as shown in figure 4-24. When these voltages are in phase, the potential at points A and B (across rectifier CR10) in figure 4-24 will be the same, so no current can flow. Now assume that the energized bus and the oncoming generator are 180° out of phase (fig. 4-25). Under these conditions the voltage at point A is a maximum in a positive direction. The voltage at point B is at a maximum in a negative direction. This causes maximum current to flow in rectifier CR10. Filtering of the rectified current is accomplished by resistor R7 and capacitor C4 (fig. 4-23). Remember that when no phase difference exists between the energized bus and the oncoming generator, the CR10 rectifier output is zero. A maximum output is developed when the difference is 180° between the two signals. The CR10 output is applied across resistors R8 and R6. At a given magnitude, the voltage drop across resistor R6 (fig. 4-21) overcomes the positive bias from base to emitter of transistor Q1 (because of Zener diode CR8). The net result is a negative bias which shuts off transistor Q1.

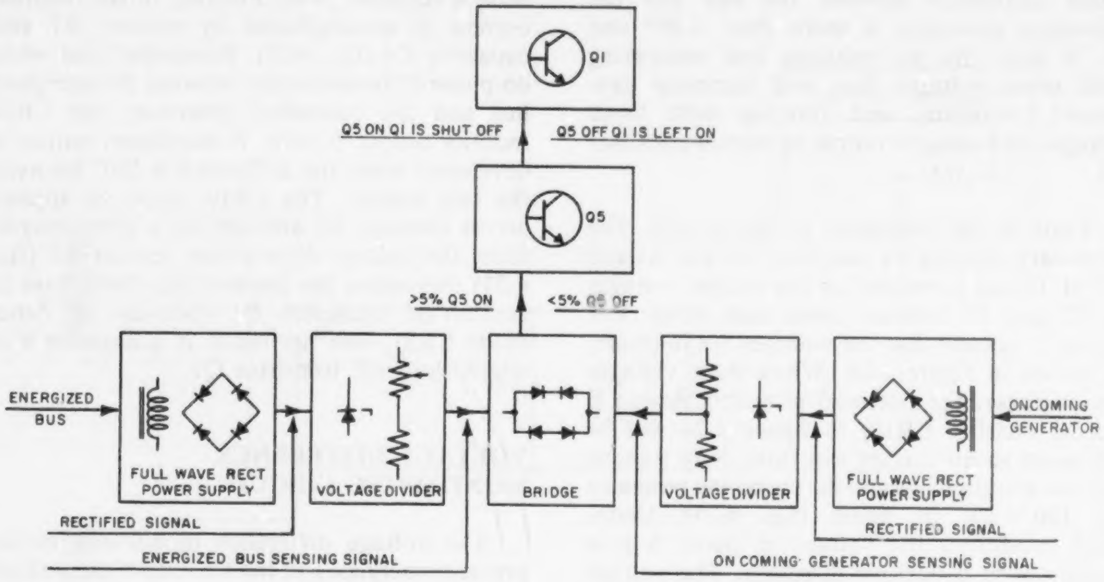
VOLTAGE DIFFERENCE MONITORING CIRCUIT

The voltage difference monitoring circuit prevents energizing of the K1 relay if the voltage difference between the bus and the oncoming generator is more than 5 percent. It does this by


A
+
BUS.
VOLT.
-
+
GEN.
VOLT.
-
B
VOLTAGE ACROSS CRIO WHEN ENERGIZED BUS AND ONCOMING GENERATOR ARE 180° OUT OF PHASE

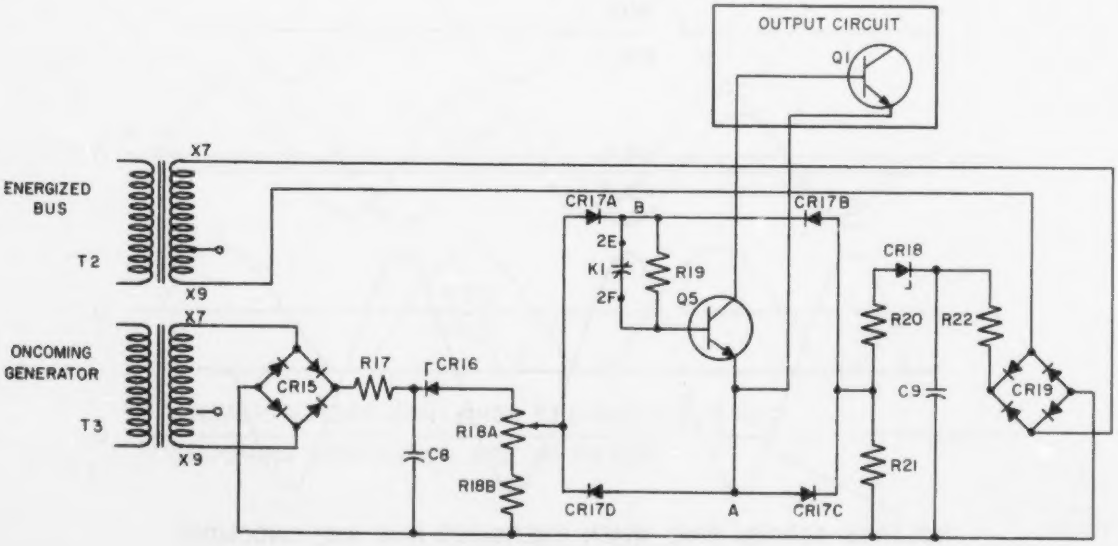
111.111

Figure 4-25.—Input voltage to CR10 (180° out of phase).


Q1
Q5 ON Q1 IS SHUT OFF
Q5 OFF Q1 IS LEFT ON
Q5
>5% Q5 ON
<5% Q5 OFF
ENERGIZED BUS
FULL WAVE RECT POWER SUPPLY
VOLTAGE DIVIDER
BRIDGE
VOLTAGE DIVIDER
FULL WAVE RECT POWER SUPPLY
ONCOMING GENERATOR
RECTIFIED SIGNAL
ENERGIZED BUS SENSING SIGNAL
RECTIFIED SIGNAL
ON COMING GENERATOR SENSING SIGNAL

111.112

Figure 4-26.—Block diagram of voltage difference monitoring circuit.


OUTPUT CIRCUIT
Q1
X7
ENERGIZED BUS
T2
X9
X7
ONCOMING GENERATOR
T3
X9
CR15
R17
CR16
R18A
C8
R18B
CR17A
B
2E
K1
2F
R19
Q5
CR17B
CR18
R20
R22
C9
CR19
R21
CR17D
A
CR17C

111.113

Figure 4-27.—Schematic diagram of voltage difference monitoring circuit.

(fig. 4-26) reducing and rectifying both input voltages (bus and incoming generator); producing and delivering a sensing signal from each input; comparing the difference in magnitude of the two sensing signals in a bridge circuit; and using transistor Q5 for an ON-OFF switch.

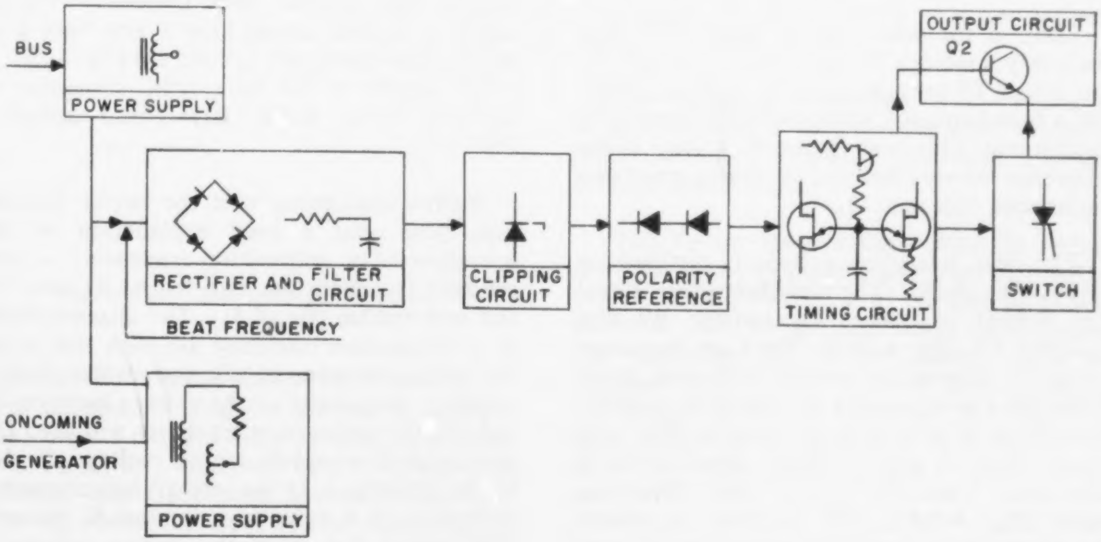
Look at the schematic in figure 4-27. You can see that the bus voltage is stepped down by windings X7 and X9 on T2. The reduced voltage is then rectified by a full-wave rectifier CR19 and filtered by R22 and C9. The same thing occurs for the oncoming generator voltage at T3. Transformer T3 steps the voltage down. CR15 rectifies it, and R17 and C8 filter it.

Zener diode CR18 is used to increase the sensitivity of voltage dividers R20 and R21 in the bus signal circuit. The Zener diode causes all the increase or decrease of the bus signal voltage to appear across the voltage divider. This also happens to voltage dividers R18A and R18B, using Zener diode CR16. The resultant signal out of each voltage divider is the sensing signal. These sensing signals are then fed to a rectifier bridge consisting of CRs 17A, B, C, and D. When the bus and the oncoming generator sensing signals are equal, there is zero voltage between the bridge (points A and B). A difference between the bus voltage and the oncoming voltage causes a voltage to exist across the bridge.

Connected between points A and B of the bridge is the emitter and base of transistor Q5. The collector of Q5 is connected to the base of Q1. The circuit is completed from the emitter of Q1 to the emitter Q5. If the voltage between A and B (across the bridge) is zero, Q5 cannot be biased on. Therefore, the base to emitter of Q1 is not shorted out. If a voltage does appear across points A and B of the bridge, which can be caused by as little as a 5 percent voltage difference between the bus and the oncoming generator, Q5 will be biased on and short out the base to emitter of Q1. This will turn off Q1 (fig. 4-21) and prevent energizing of relay K1. Resistor R19 prevents small momentary changes in voltage differences from turning on Q5 once relay K1 has picked up.

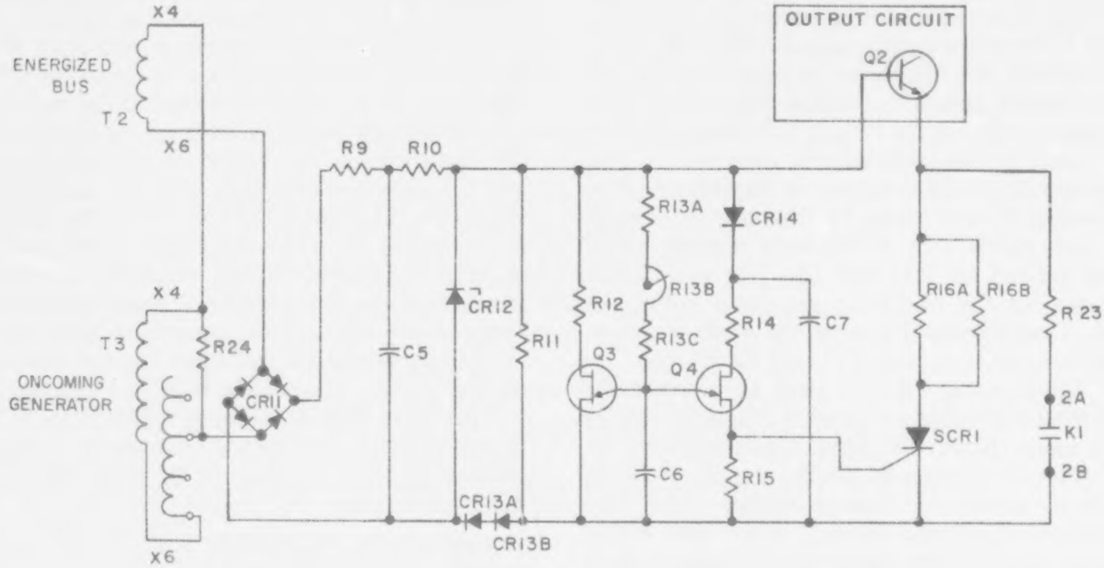
FREQUENCY DIFFERENCE MONITORING CIRCUIT

This circuit prevents energizing of relay K1 if the frequency difference between the bus and the oncoming generator is more than 0.2 hertz. It does this by changing both frequency signals into a beat frequency voltage (fig. 4-28). It rectifies, filters,



111.114

Figure 4-28.—Block diagram of frequency difference monitoring circuit.



111.115

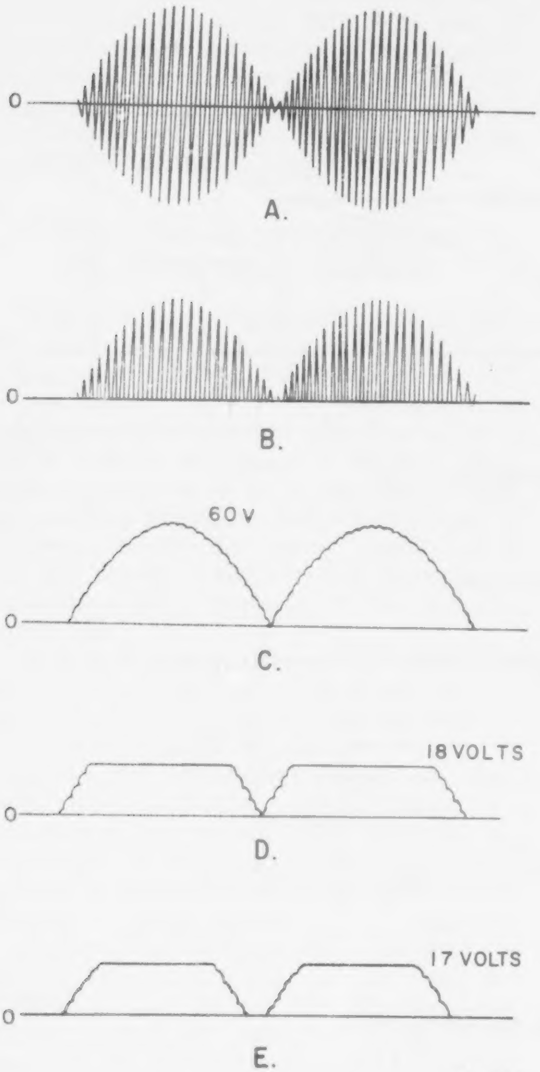
Figure 4-29.—Schematic diagram of frequency difference monitoring circuit.

and reduces the beat frequency voltage. It then uses the beat frequency voltage in a timing circuit to fire an SCR.

Look at the schematic in figure 4-29. The secondary windings X4 and X6 of T2 and X4 and X6 of T3 are connected in such a manner that a beat frequency voltage (heterodyne wave) is generated. This beat frequency voltage is the difference between bus and oncoming generator frequencies (fig. 4-30A).

The beat frequency voltage is rectified by CR11 (fig. 4-29). The resultant d.c. signal (fig. 4-30B) is filtered by resistor R9 and capacitor C5 (fig. 4-30C). The beat frequency voltage is clipped by resistor R10 and Zener diode CR12 to a constant d.c. level (fig. 4-30D). The signal is now sent to resistor R11 and diode CR13 (A and B). Here about 1 volt is subtracted from the clipped beat frequency signal (fig. 4-30E). This is done to ensure the clipped beat frequency voltage signal goes to zero when the original beat frequency goes to zero. At this point, the signal is a rectified, filtered, clipped beat frequency voltage signal (heterodyne wave). The final step is to take this signal and feed it to the unijunction timing circuit. The clipped beat frequency voltage signal is applied across base 1 and base 2 of unijunction transistors Q3 and Q4 (fig. 4-29). It is also applied to the RC circuit, consisting of resistors R13A, R13B, R13C, and capacitor C6.

Before continuing with the circuit description, you need a brief explanation of the operation of a unijunction transistor. A unijunction transistor has two bases, B1 and B2, and one emitter (fig. 4-31). The characteristics of a unijunction transistor are such that when the voltage between B1 and the emitter rises to a certain percentage of the voltage between B1 and B2, the unijunction transistor will fire. The percentage is equal to emitter voltage divided by the B2 voltage. In the case of the unijunction transistors, it is equal to a nominal 62 percent. This means that when the emitter voltage is approximately 60 percent of B2 voltage, both in reference to B1, the unijunction transistor

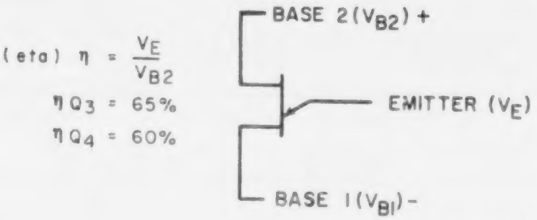


111.116

Figure 4-30.—Beat frequency voltages.

will fire. By understanding that Q3 and Q4 have different values for the same voltage; that C6 has a definite charging rate (determined by R9, R10, R13, and rectifier CR14); and that different beat frequencies have different time intervals, you should have a basic understanding of how the timing circuit operates.

For the following examples, the values used are arbitrary. Let us use two examples to show



111.117

Figure 4-31.—Unijunction transistor.

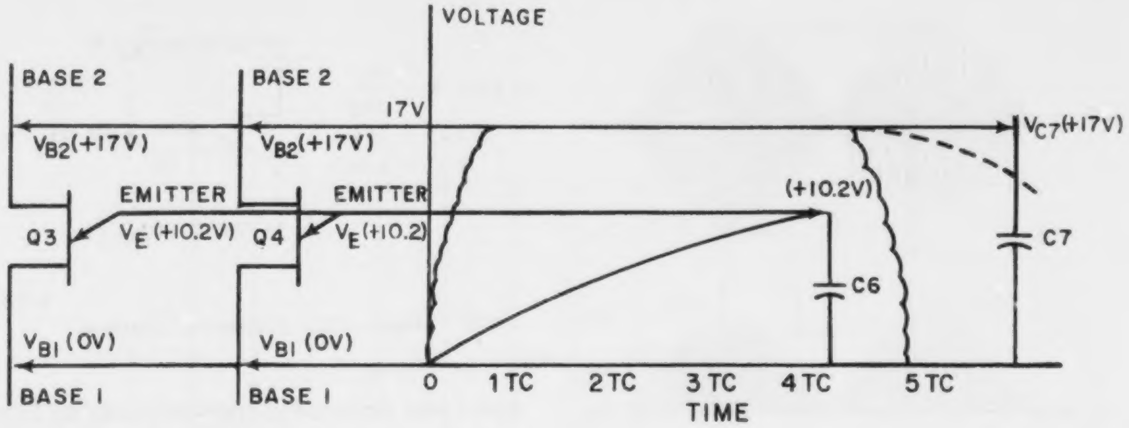
how these unijunction transistors can be fired. In the first example (fig. 4-32), there is a difference of 0.2 hertz in the beat frequency voltage. This causes a time period of 5 time constants for one cycle. Within the 5 time constant period, the following events will occur.

The voltage across Q3 and Q4 increases sharply and remains at 17 volts until the end of the cycle. The 17 volts are applied across B1 and B2 of unijunction transistors Q3 and Q4, across capacitor C7, and across the RC circuit containing C6. Capacitor C7 blocks rectifier CR14 and therefore will maintain approximately 17 volts. The only place C7 can discharge is through Q4, which has a very low leakage rate.

The RC circuit containing C6 is charging at a specific rate. If we assume that within 4 time constants C6 reaches 10.2 volts, then the following will occur.

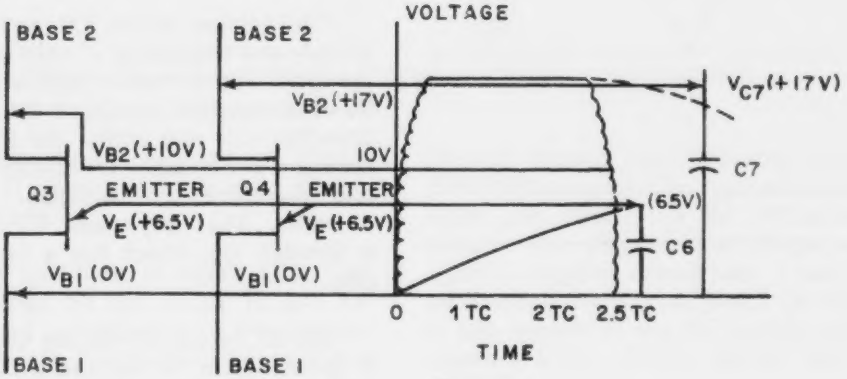
The V_E for Q4 will fire before Q3. When Q4 fires, a voltage pulse is generated across R15 (fig. 4-29) and is applied to the gate of SCR1. SCR1 is then turned on. When SCR1 turns on, transistor Q2 in the output circuit is supplied with a base current through limiting resistor R16. This turns on Q2. When the beat frequency voltage goes to zero, SCR1 turns off. The timing process then repeats itself.

In the second example (fig. 4-33), there is a difference of 4.0 hertz in the beat frequency voltage. This causes a time period of half the


VOLTAGE
BASE 2
BASE 2
17V
VB2(+17V)
VB2(+17V)
VC7(+17V)
EMITTER
EMITTER
(+10.2V)
Q3
VE (+10.2V)
Q4
VE(+10.2)
C7
C6
VB1 (0V)
VB1 (0V)
BASE 1
BASE 1
0
1 TC
2 TC
3 TC
4 TC
5 TC
TIME

111.118

Figure 4-32.—Firing sequence for Q4.


VOLTAGE
BASE 2
BASE 2
VB2 (+17V)
VC7(+17V)
VB2(+10V)
10V
C7
Q3
EMITTER
Q4
EMITTER
(6.5V)
VE (+6.5V)
VE (+6.5V)
C6
VB1 (0V)
VB1 (0V)
0
1 TC
2 TC
2.5 TC
TIME
BASE 1
BASE 1

111.119

Figure 4-33.—Firing sequence for Q3.

previous example. Within this period of 2.5 time constants, the following events occur:

The voltage across Q3 and Q4 increases sharply and remains at 17 volts until the end of the cycle. The 17 volts are applied across B1 and B2 of unijunction transistors Q3 and Q4. It is also applied across capacitor C7 and across the RC circuit containing C6. Capacitor C6 charges at the same rate as before (assuming 10.3 volts in 4 time constants). The period of time for this cycle is only 2.5 time constants. Therefore, the voltage across C6 can only reach approximately 6.5 volts within this time.

At the end of 2.5 time constants, approximately 17 volts are held across Q4 by capacitor C7, with a sharp decrease of voltage across B1 and B2 of Q3. When the voltage reaches approximately 10 volts, Q3 can fire because of its relative value of this voltage. Q4 still has approximately 17 volts across it.

After Q3 fires and the beat frequency goes to zero, the time process again repeats itself.

You can see that different beat frequencies are compared just as the differences were in phase and voltage. The function of the frequency difference circuit is to energize relay K1 through the control of transistor Q2, if the difference of the frequency of the bus and the oncoming generator is less than 0.2 hertz.

SERVICING TECHNIQUES FOR TRANSISTORIZED CIRCUITS

There are many differences between transistorized and electron tube circuits from the standpoint of servicing. For instance, you rely on your senses of sight, touch, and smell in the visual inspection of electron tube circuits. This is not as feasible in transistor circuits. Many transistors develop so little heat that you can learn nothing by feeling them. High-frequency transistors hardly get warm. Usually, if a transistor (except a high-powered transistor) is hot enough to be noticeable, it has been damaged beyond use.

In electron tube circuits, you often make a quick test by the tube substitution method. You replace the tube suspected of being bad with one you know to be good. In solid state circuits, the transistors are frequently soldered in. This makes the substitution method impractical. Furthermore, you should avoid indiscriminate substitution of transistors and other semiconductors. You should test transistors with an approved transistor test set.

Most good quality test equipment used for electron tube testing can also be used for transistor circuit testing. You can use signal generators, both RF and AF, if the power supply in the equipment is isolated from the power line by a transformer.

CAUTION: Before you make any tests with a signal generator, connect a common ground wire from the chassis of the equipment to be tested to the chassis of the signal generator before you make any other connection.

You can use signal tracers (such as dual trace oscilloscopes) on transistor circuits if you observe the precautions concerning the power supplies. Many signal tracers use transformerless power supplies. To prevent damage to the transistor, use an isolation transformer.

Multimeters used for voltage measurements in transistor circuits should have a high ohms/volt sensitivity to ensure an accurate reading. This should be at least 20,000 ohms/volt.

Ohmmeter circuits which pass a current of more than 1 milliampere through the circuit under test cannot be used safely in testing transistor circuits. Before using an ohmmeter on a transistor circuit, check how much current it passes on all range settings. Do not use any range that passes more than 1 milliampere.

Conventional test prods, when used in the closely confined areas of transistor circuits, often are the cause of accidental shorts between adjacent terminals. In electron tube circuits the momentary short caused by test prods rarely results in damage. However, in transistor circuits this short can destroy a transistor. Also, since transistors are very sensitive to improper bias voltages, you must avoid the practice of troubleshooting by shorting various points to ground and listening for a click. When you test transistor circuits, remember the vulnerability of a transistor to surge currents.

SUMMARY

After completion of this chapter you should have a good idea of the types of voltage and frequency regulators in use today. We have discussed their individual characteristics. If you desire further information, you may refer to the following references.

REFERENCE

NAVSEA S9086-KN-STM-000, chapter 310

[illegible]

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CHAPTER 5

ELECTROHYDRAULIC LOAD-SENSING SPEED GOVERNORS

This chapter will discuss the operation and maintenance of electrohydraulic load-sensing speed governors. If you do not have a thorough understanding of solid state circuitry, components, or terms, review the Navy Electricity and Electronics Training Series (NEETS). Pertinent modules are 6 through 9—NAVEDTRA numbers 172-06-00-82, 172-07-00-83, 172-08-00-82, and 172-09-00-83.

Electrohydraulic load-sensing speed governors have been developed for the ship's service generators in electrical systems which require closer frequency regulation than that provided by mechanical-type governors. Electrohydraulic governors have been used successfully on steam turbine, gas turbine, and diesel-driven generators.

An electrohydraulic governor may be operated as an isochronous governor. This is where you have constant speed regardless of load. This is provided the load does not exceed the limits of the prime mover. A governor of this type may also be used with speed droop. This is where as the load increases, the speed of the prime mover decreases. This permits paralleling with other generators that have dissimilar governors or paralleling with an infinite bus (such as shore power).

The operation of a typical electrohydraulic load-sensing governoring system may be generally described as follows: The throttle that controls the prime mover fuel medium is operated by an electrohydraulic actuator. This actuator responds to the output of an electronic amplifier. Generator speed and load signals are fed into the electronic amplifier. This produces a power output which operates the electrohydraulic actuator. This, in turn, correctly positions the steam valve or throttle.

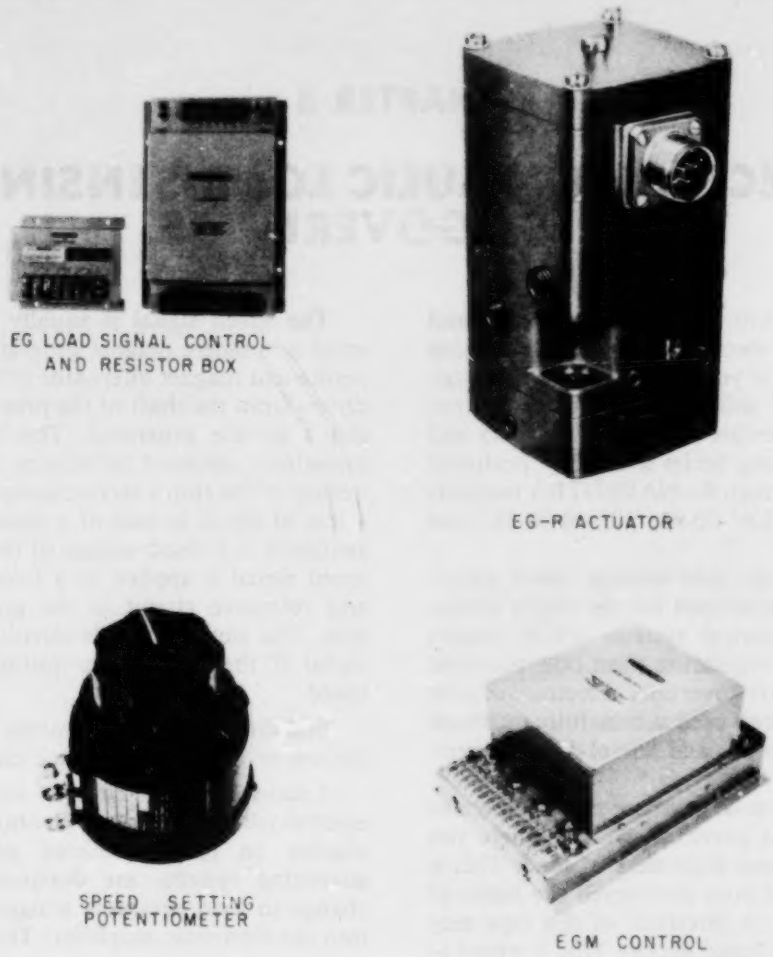
The speed signal is usually provided by a small permanent magnet generator (PMG) or a permanent magnet alternator (PMA). These are driven from the shaft of the prime mover on the ship's service generator. The speed signal is sometimes obtained by sensing the output frequency of the ship's service generator. However, a loss of signal in case of a short circuit on the generator is a disadvantage of this method. The speed signal is applied to a frequency sensitive and reference circuit in the governor control unit. The output of this circuit is a net error signal if there is any deviation from the set speed.

Stability of the prime mover is obtained by the use of electrical feedback circuits.

Load-measuring circuits are used in the electrohydraulic governor to obtain proper load sharing on each paralleled generator. Most governing systems are designed so that any change in load produces a signal which is fed into the electronic amplifier. This acts to offset any anticipated speed change caused by load change. The load-measuring circuits of governors on all generators that operate in parallel are connected by a bus tie cable. The governor may be designed or preset so that each paralleled generator will equally share the total load. If not, a load-sharing adjustment must be provided.

The steady state and transient frequency requirements for type II power can be met with electrohydraulic governors of the type just described. However, a motor generator or static converter will still be required for type III voltage control.

The electrohydraulic load-sensing governor used in this discussion is made up of three separate


EG LOAD SIGNAL CONTROL AND RESISTOR BOX
EG-R ACTUATOR
SPEED SETTING POTENTIOMETER
EGM CONTROL

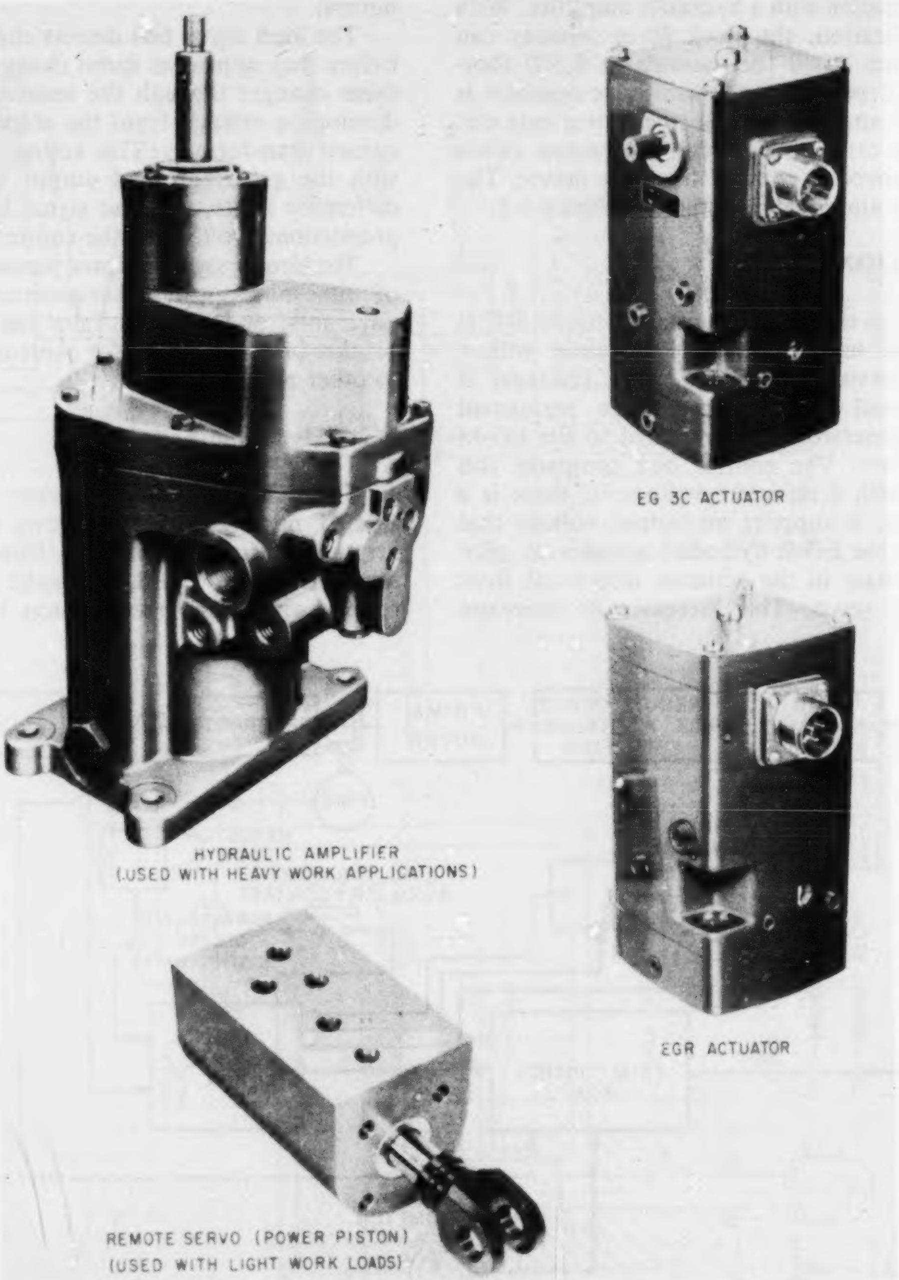
111.198X

Figure 5-1.—Electrohydraulic load-sensing governor system components.

assemblies (fig. 5-1). These are an EG-M control box, a speed adjusting potentiometer, and a hydraulic actuator. Depending upon the control box and the type of service in which it is used, the load signal box and a resistor box may be required.

EG-M SYSTEM

The EG-M electrohydraulic governor system offers diversified work capabilities. Large or small prime mover governor requirements can be met by the use of the EG-3C, the EG-R, a hydraulic amplifier, and the EG-R hydraulic actuator. The EG-3C hydraulic actuator, shown in figure 5-2, has a working capacity of 3 foot-pounds. It is capable of controlling small diesel engines. The EG-R hydraulic actuator, shown in figure 5-2, has a working capacity of 20 foot-pounds. This governor requires the use of a remote servo. It is capable of controlling steam turbine prime movers with small working


EG 3C ACTUATOR
HYDRAULIC AMPLIFIER
(USED WITH HEAVY WORK APPLICATIONS)
EGR ACTUATOR
REMOTE SERVO (POWER PISTON)
(USED WITH LIGHT WORK LOADS)

111.199X

Figure 5-2.—EG-M electrohydraulic governor systems.

capacities. The EG-R actuator is sometimes used in combination with a hydraulic amplifier. With this application, the work force capacity can range from 1,800 foot-pounds to 6,500 foot-pounds, depending on which valve operator is used and what the work load requirements are. With this arrangement very large steam valves can be moved to control the prime mover. The hydraulic amplifier is pictured in figure 5-2.

OPERATION

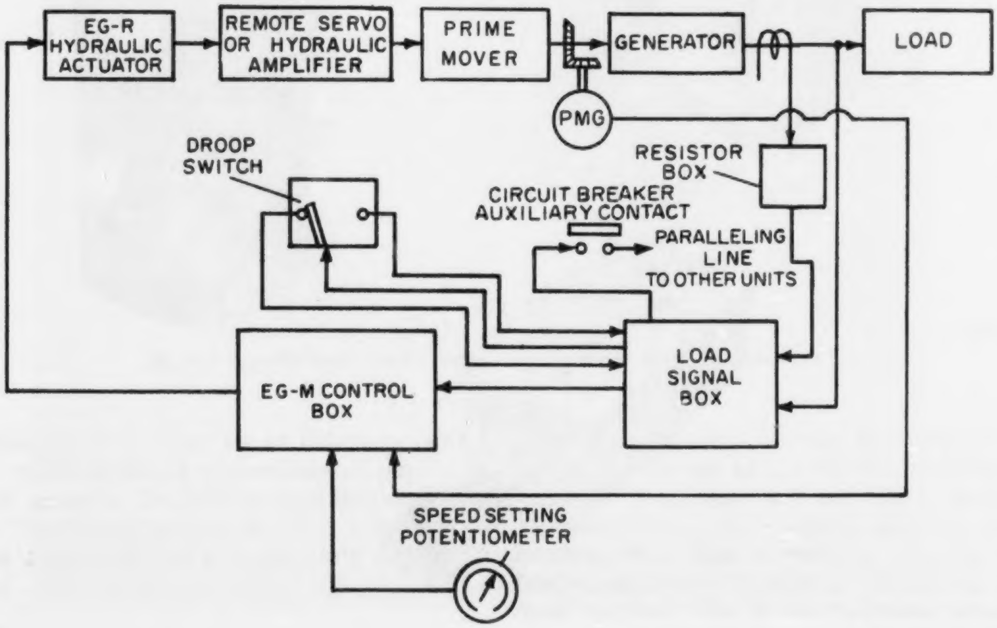
Look at the block diagram of figure 5-3. It shows the use of the EG-R actuator with a remote servo. The input signal (voltage) is proportional to the speed of a permanent magnet generator and is applied to the EG-M control box. The control box compares this voltage with a reference voltage. If there is a difference, it supplies an output voltage that energizes the EG-R hydraulic actuator. A pilot valve plunger in the actuator directs oil from a remote servo. This increases or decreases the steam which returns the turbine speed to normal.

The load signal box detects changes in load before they appear as speed changes. It detects these changes through the resistor box which develops a voltage from the secondary of the current transformers. This voltage is compared with the generator load output voltage. If a difference exists, the load signal box applies a proportional voltage to the control box.

The droop switch allows parallel operation of prime movers with similar governors, dissimilar governors, or with an infinite bus. The circuit breaker provides a path for control load signals to other paralleled units.

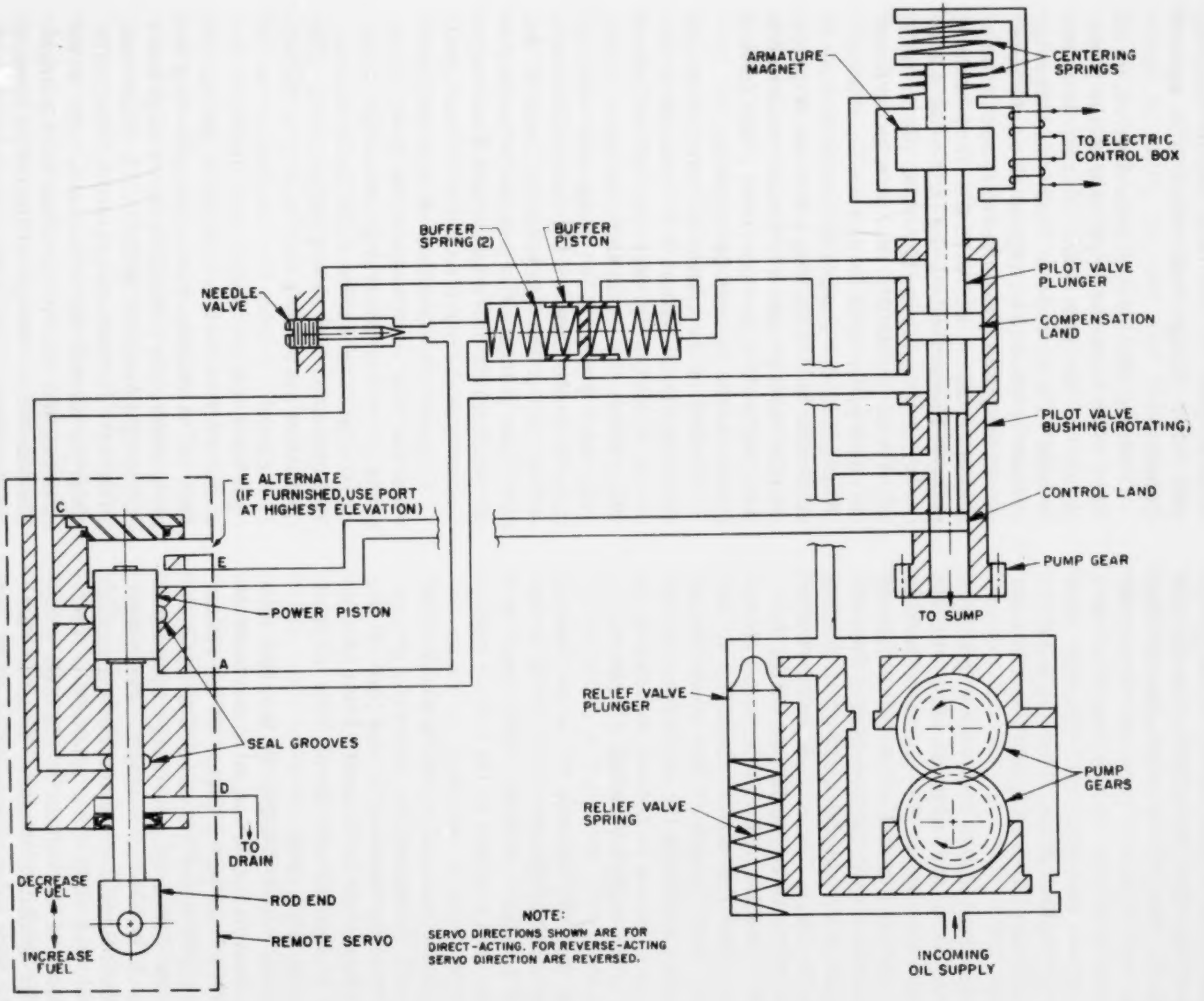
EG-R Hydraulic Actuator

The EG-R hydraulic governor will be considered next. Figure 5-4 shows a schematic arrangement of this governor. Note that in this application the EG-R hydraulic actuator is coupled with a remote servo piston. High-pressure


EG-R HYDRAULIC ACTUATOR
REMOTE SERVO OR HYDRAULIC AMPLIFIER
PRIME MOVER
GENERATOR
LOAD
PMG
DROOP SWITCH
RESISTOR BOX
CIRCUIT BREAKER AUXILIARY CONTACT
PARALLELING LINE TO OTHER UNITS
LOAD SIGNAL BOX
EG-M CONTROL BOX
SPEED SETTING POTENTIOMETER

111.151

Figure 5-3.—Electrohydraulic load-sensing governor system, block diagram.


ARMATURE MAGNET
CENTERING SPRINGS
TO ELECTRIC CONTROL BOX
BUFFER SPRING (2)
BUFFER PISTON
NEEDLE VALVE
PILOT VALVE PLUNGER
COMPENSATION LAND
PILOT VALVE BUSHING (ROTATING)
CONTROL LAND
PUMP GEAR
TO SUMP
E ALTERNATE (IF FURNISHED, USE PORT AT HIGHEST ELEVATION)
C
E
A
D
POWER PISTON
SEAL GROOVES
TO DRAIN
DECREASE FUEL
INCREASE FUEL
ROD END
REMOTE SERVO
NOTE:
SERVO DIRECTIONS SHOWN ARE FOR DIRECT-ACTING. FOR REVERSE-ACTING SERVO DIRECTION ARE REVERSED.
RELIEF VALVE PLUNGER
RELIEF VALVE SPRING
PUMP GEARS
INCOMING OIL SUPPLY

111.200X

Figure 5-4.—Schematic arrangement of the EG-R actuator.

lines provide the means of connecting the actuator to the remote servo. Oil from an external source enters the suction side of the oil pump. The pump gears carry the oil to the pressure side of the pump. This fills the oil passages and then increases the hydraulic pressure. When the pressure becomes great enough, the relief valve spring force is overcome, and the relief valve plunger is pushed down. This uncovers the bypass hole and allows oil to recirculate through the pump.

The linear movement of the power piston in the remote servo, used in conjunction with the EG-R actuator, moves the engine or turbine linkage. The EG-R actuator controls the flow of pressure oil to or from the servo piston. Pressure oil from the pump is supplied directly to one end of the buffer piston. The other end on the buffer piston connects to the underside of the servo piston. Pressure in this hydraulic circuit always tends to move the power piston up in the "decrease fuel" direction. The power piston cannot move up unless the oil trapped on top of the power piston is allowed to drain. It is drained to the sump by raising the pilot valve plunger.

When you are starting the prime mover, manually controlling the speed of the prime mover is necessary until an input signal and power becomes available to the control box.

A drive force is necessary to rotate the actuator pump gears and provide a relative rotation between the nonrotating pilot valve plunger and its rotating bushing. Upon loss of the electrical signal, the EG-R and EG-3C hydraulic actuator can go to shutdown. This depends upon design application.

The pilot valve plunger in the hydraulic actuator controls the flow of oil to and from the upper side of the power piston in the remote servo. The pilot valve is connected to an armature magnet. This magnet is spring-suspended in the field of a two-coil solenoid. The output signal from the electronic control box is applied to the solenoid coils. This produces a force, proportional to the current in the coil, which moves the armature magnet. This, in turn, moves the pilot valve plunger up or down. An electronic amplifier is housed in the electronic control box (fig. 5-1). When a positive d.c. voltage is sent to the actuator from the control box, the pilot valve travels in a downward direction. If a negative d.c. voltage is sent to the actuator from the electronic control box, the pilot valve plunger will travel in a upward direction.

With the pilot valve plunger centered, no oil flows to or from the upper side of the power piston. If the pilot valve plunger is raised because of a decrease in load, this causes an increase in speed. The trapped oil on the upper side of the piston is then free to escape to sump. It escapes past the control land on the pilot valve plunger. Pressure oil on the right-hand side of the buffer piston forces the buffer piston to the left. The oil displaced by the buffer piston forces the power piston up in the decrease fuel direction. If the pilot valve plunger is lowered because of an increase in load (causing a decrease in speed), the pilot valve plunger is lowered. Pressure oil is then sent to the top of the power piston forcing it down in the increase fuel direction.

Stability of the system is controlled by the electric governor section. It is enhanced by the use of a temporary negative feedback signal which biases the speed and load signal to the pilot valve plunger. The temporary feedback signal is in the form of a pressure differential applied across the compensating land of the pilot valve plunger. The pressure differential is derived from the buffer system and is allowed to fade away as the engine returns to normal speed.

Consider the operation of a prime mover when the load decreases and the speed of the prime mover increases. A regulated negative d.c. signal is sent to the solenoid inside the actuator. This causes the pilot valve plunger to raise. This then causes the buffer piston to move to the left. This partially relieves the compression on the right-hand buffer spring and increases the compression of the left-hand buffer spring. The force of the left-hand buffer spring resisting this movement results in a slightly higher oil pressure on the right-hand side of the buffer piston than on the left. The pressure on the left of the buffer piston is transmitted to the underside of the compensation land of the pilot valve plunger. The pressure on the right of the buffer piston is fed to the upper side of the compensation land. The difference in pressure on the two sides produces a force which acts to push the pilot valve plunger back down to its centered position.

When the plunger is raised, trapped oil on top of the power piston drains to sump. The power piston then travels in a decrease fuel direction. When the power piston moves far enough to satisfy the new fuel requirement, the force of the pressure differential on the compensating land will have recentered the pilot valve plunger. This takes place even though engine speed is not yet back to steady state. In recentering the pilot valve plunger, power piston movement is stopped. Any further movement of the plunger is hampered by a compensating force across the compensating land. This was created by the movement of the buffer piston. This force opposes the electrical signal that is still present. The electrical signal will fade to its on-speed voltage value as the prime mover returns to its steady-state speed. At the same time, the pressure differential on the two sides of the buffer piston and on the upper and lower side of the compensating land is being dissipated. It is dissipated by the flow of oil through the needle valve orifice. As this occurs the buffer springs return the buffer piston to normal centered position. The decrease in electrical signal to its on-speed valve and the dissipation of the differential pressure on the two sides of the compensation land occur at the same rate. As this occurs the pilot valve remains centered until the prime mover is again at the set steady speed. However, there is now less fuel requirement caused by the load decrease.

Note that the actuator pilot valve plunger traveled in an upward direction when it received a negative d.c. signal. When a negative d.c. signal is sent to the actuator from the electronic amplifier, it will always call for a decrease in fuel.

Now consider the operation when the prime mover load increases and prime mover speed decreases. The pilot valve plunger is lowered caused by a regulated positive d.c. signal that was sent to the solenoid inside the actuator. Pressure oil flows to the upper side of the remote servo piston. Because the area against which the oil pressure acts on the upper side of the servo piston is greater than the area against which the oil on the lower side of the piston acts, the net force moves the piston in the increase fuel direction. The oil displaced on the left side of the buffer piston increases the compression of the right-hand buffer spring and partially relieves the compression of the left-hand buffer spring. This movement caused a pressure differential on the upper and lower sides of the compensation land. In this case there is a higher pressure on the top surface of the compensating land than on the bottom. This forces the pilot valve plunger down to its centered position before the prime mover speed returns to normal. This pressure differential dissipates through the needle valve orifice at the same rate that the electrical signal is reduced to its on-speed voltage. This allows the prime mover speed to return to normal. The prime mover thus returns to its steady-state condition. The remote servo piston is then at the new fuel position (increased) required for the increase in prime mover load.

Note that the actuator pilot valve plunger traveled in a downward direction when it received a positive d.c. signal. When a positive d.c. signal is sent to the actuator from the electronic amplifier, it will always call for an increase in fuel.

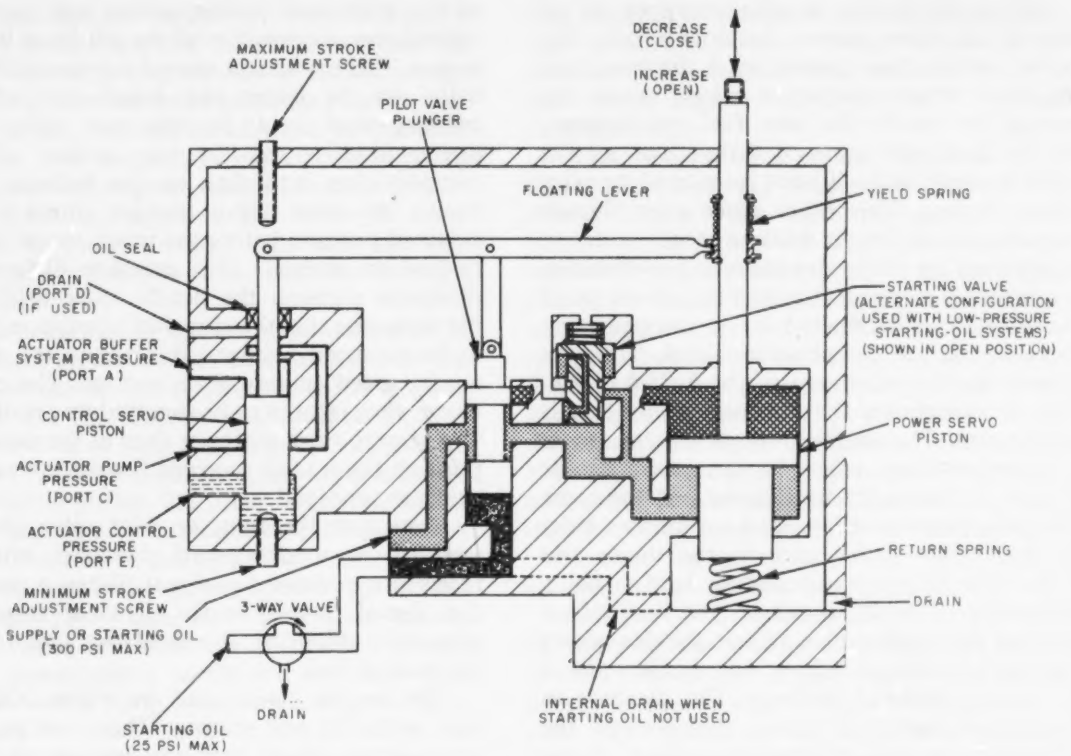
The power piston and its piston rod are surrounded by seal grooves. These seal grooves are used to ensure that any leakage of pressure oil from the power piston comes from a part of the hydraulic circuit where it will do no harm.

Hydraulic Amplifier

The hydraulic amplifier is a linear pilot-operated servo actuator. It is used where relatively large forces are required to operate power control mechanisms, such as turbine steam valves or the fuel control linkage of large engines.

When you are using a hydraulic amplifier in conjunction with the EG-R actuator, a remote servo piston is not used. The various ports of the actuator are directly connected to the amplifier with high-pressure lines. The control servo piston, which is an integral part of the amplifier, is used in place of the remote servo piston. This controls the movement of the hydraulic amplifier pilot valve plunger.

The use of a three-way valve, a starting valve and a yield spring are necessary starting aids. These will be discussed later.


MAXIMUM STROKE ADJUSTMENT SCREW
PILOT VALVE PLUNGER
DECREASE (CLOSE)
INCREASE (OPEN)
FLOATING LEVER
YIELD SPRING
OIL SEAL
DRAIN (PORT D) (IF USED)
ACTUATOR BUFFER SYSTEM PRESSURE (PORT A)
CONTROL SERVO PISTON
ACTUATOR PUMP PRESSURE (PORT C)
ACTUATOR CONTROL PRESSURE (PORT E)
MINIMUM STROKE ADJUSTMENT SCREW
SUPPLY OR STARTING OIL (300 PSI MAX)
3-WAY VALVE
DRAIN
STARTING OIL (25 PSI MAX)
STARTING VALVE (ALTERNATE CONFIGURATION USED WITH LOW-PRESSURE STARTING-OIL SYSTEMS) (SHOWN IN OPEN POSITION)
POWER SERVO PISTON
RETURN SPRING
DRAIN
INTERNAL DRAIN WHEN STARTING OIL NOT USED

111.201X

Figure 5-5.—Hydraulic amplifier schematic diagram.

The hydraulic amplifier does not have its own oil pump. Consequently, operating oil pressure and supply must come from an external source (usually the prime mover lubricating system).

The use of a starting oil pump is necessary when the prime mover is being started. Once the prime mover develops its own pressure, this pump is secured. Refer to figure 5-5 for a schematic diagram of the hydraulic amplifier. The control ports are connected to correspondingly identified ports in the EG-R actuator. Actuator buffer compensation system pressure (port A) always tends to move the amplifier control servo piston downward (decrease fuel or steam). Actuator control pressure (port E) tends to move the control servo piston upward (increase fuel or steam). Pressure in the compensation or buffer port and the control port are constant at steady state for all control servo piston positions. Control oil pressure is approximately one half the compensation oil pressure. The control oil pressure varies during a transient while the compensation oil pressure changes slightly. The variations in control oil pressure causes the control piston to move. Actuator pump output pressure (port C) is connected to annular seal grooves in the control piston and piston rod bores. This ensures that any oil leakage comes from a part of the hydraulic circuit where it does not adversely affect control pressure or oil flow.

The control piston is connected to one end of a floating lever in the amplifier. Any change in position of the control piston is transmitted to the floating lever. The movement of the floating lever is transmitted to the pilot valve plunger. This controls the flow of oil to or from the power servo cylinder and piston.

When the electrical control unit senses an underspeed condition, it signals for an increase in speed (caused by an increase in load or speed setting). The pilot valve plunger in the EG-R actuator then directs oil to port E in the amplifier at increased pressure. The increase in control pressure input displaces the amplifier control servo piston upward. This causes an increase in pressure in the buffer system (port A). This, in turn, displaces the buffer piston in the EG-R actuator. The upward movement of the amplifier control piston raises one end of the floating lever. This lifts the amplifier pilot valve plunger. This admits oil at supply pressure (less the pressure drop occurring across the pilot valve) to the opening (increase) side of the power servo cylinder. Although the oil pressure on the opening side of the power servo piston is lower than that on the closing side, it acts over a much larger surface area. This causes the piston to move in the opening direction and increases power (fuel). As the power piston moves, the end of the floating lever connected to the piston rod also moves in the same direction. This gradually recenters the land on the pilot valve over the oil control port. This stops movement of the power servo piston just as the fuel control or steam valve reaches its new position as called for by the electrical control unit.

During an on-speed condition, the control signal to port E is maintained at a given pressure. The amplifier pilot valve plunger is held in its centered position. This covers the oil control port. With flow of oil to the opening side of the power servo piston blocked, except to compensate for leakage, the power piston will maintain its position in relation to the speed setting of the electric control (hydraulic actuator) or load on the prime mover.

When the electrical control unit senses an overspeed condition, it signals for a decrease in speed (caused by a decrease in load or speed setting). The pilot valve plunger in the EG-R actuator then allows oil to drain from port E in the amplifier. The decrease in the control pressure inlet allows the buffer system pressure (port A) to displace the amplifier control servo piston downward. The downward movement of the control piston lowers one end of the floating lever. This pushes the pilot valve plunger down. This then allows oil to drain from the opening side or the power servo piston. The oil pressure acting on the opposite side of the power piston along with the return spring force causes the power piston to move in the closing direction (decrease fuel). Movement of the power servo piston continues until the amplifier pilot valve plunger is again recentered by the floating lever.

In some applications the steam valve or fuel control must be opened before starting the prime mover. If this is necessary, you must use a three-way valve, a starting valve, and a yield spring. The yield spring and starting valve is an integral part of the hydraulic amplifier. The three-way valve is an external component. An additional tube connection must also be made on the hydraulic amplifier. This provides a passage for starting oil (which is developed from a hand pump or an electric-driven oil pump) to move the hydraulic amplifier pilot valve plunger on startup. This connection allows oil (25 psi minimum) to be used to raise the hydraulic amplifiers pilot valve plunger and direct starting oil to the power servo piston. This is necessary since the EG-R hydraulic actuator is inoperative on initial startup. The yield spring permits one end of the floating lever to move upward when starting oil is applied to the bottom side of the pilot valve plunger. You must turn the three-way valve to drain after starting. Otherwise, oil will be trapped under the pilot valve plunger. This will render the amplifier inoperative.

In this low-pressure-starting-oil system, the starting valve minimizes the force acting on the closing side of the power servo piston. Starting oil pressure within the range of 25 to 30 psi (typical) cannot generate sufficient force on the opening side of the power piston to overcome the combined forces of low oil pressure and return spring force on the closing side of the power servo piston.

In the shutdown position, the starting valve blocks the flow of starting oil to the closing side of the power piston. It also simultaneously opens the area to drain. When the prime mover starts and the normal supply pressure (prime mover oil pressure) becomes greater than the starting oil pressure, the increasing pressure is sensed through the axial passage in the starting valve plunger. Oil flow into the area under the large diameter of the starting valve plunger begins to lift the valve against the opposing spring force. When the pressure of the supply oil reaches a predetermined pressure (somewhat less than operating pressure), the valve opens. This closes the drain passage and opens the control port. Supply oil is then admitted to the closing side of the power servo piston. The starting valve remains in the open position during normal operation. At shutdown, spring force returns the plunger to the closed position.

EG-M Control Box

The EG-M control box is designed to provide the control signal to the electrohydraulic transducer in the hydraulic actuator.

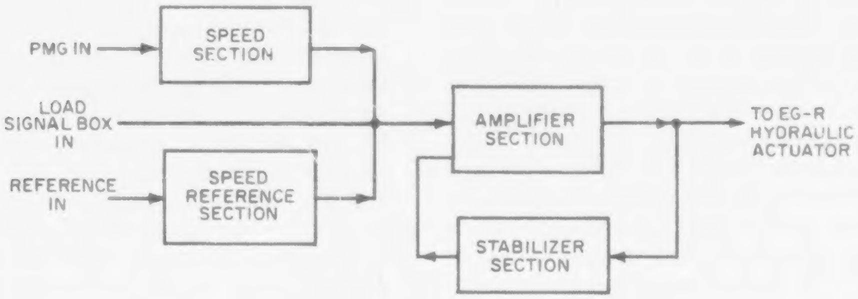

PMG IN
SPEED SECTION
LOAD SIGNAL BOX IN
AMPLIFIER SECTION
TO EG-R HYDRAULIC ACTUATOR
REFERENCE IN
SPEED REFERENCE SECTION
STABILIZER SECTION

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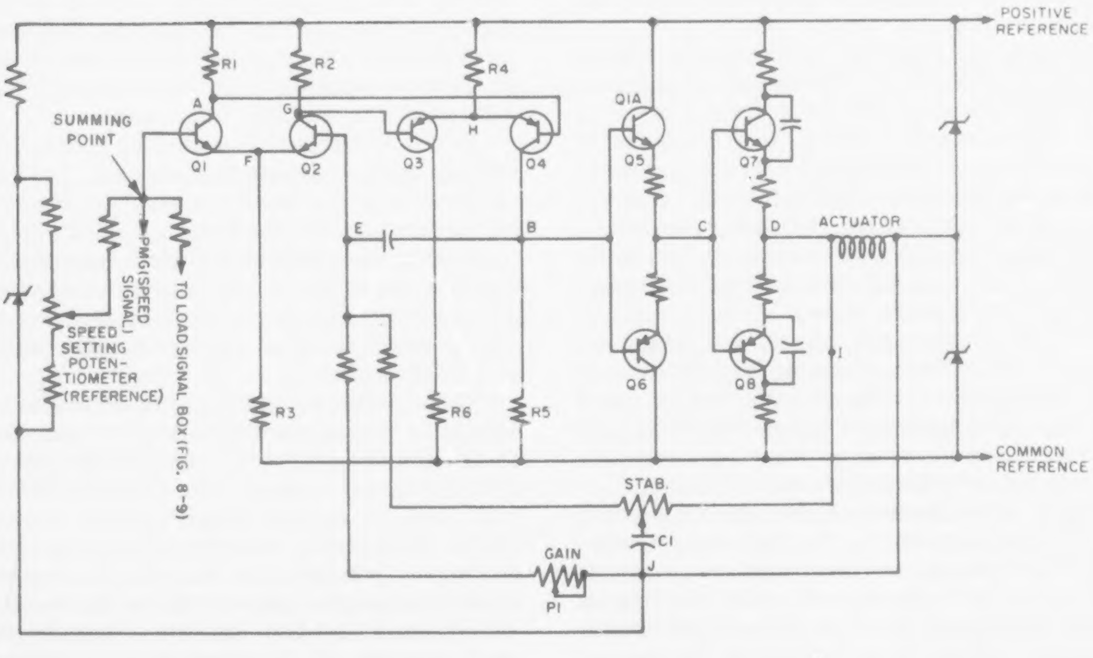
Figure 5-6.—EG-M control box, block diagram.


POSITIVE REFERENCE
R1
R2
R4
A
G
H
Q1A
SUMMING POINT
Q1
F
Q2
Q3
Q4
Q5
Q7
E
B
C
D
ACTUATOR
PMG (SPEED SIGNAL)
TO LOAD SIGNAL BOX (FIG. 8-9)
SPEED SETTING POTENTIOMETER (REFERENCE)
Q6
Q8
I
R3
R6
R5
COMMON REFERENCE
STAB.
C1
GAIN
J
P1

111.155

Figure 5-7.—EG-M control box, simplified schematic.

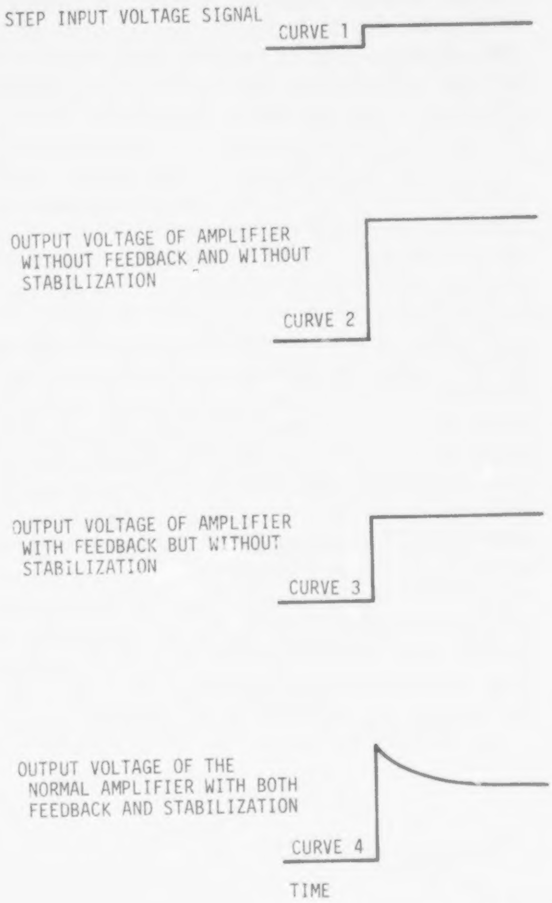
As shown in the block diagram of figure 5-6, the control box has three inputs. One is from the load signal box and will be discussed later. The other two are from the PMG and the speed setting (reference) potentiometer.

The input from the PMG is applied to the speed section where it is converted into a negative d.c. voltage. This voltage is proportional to the speed of the turbine. The positive reference voltage (speed control) is established by the speed setting potentiometer but is developed internally.

The outputs of the speed section and the speed reference section are compared. If equal and of opposite polarity, no signal is applied to the amplifier section. If the speed of the turbine changes, there is a corresponding change in the signal from the PMG. This causes a change in the output of the speed section. An error voltage is then applied to the amplifier section. This is amplified and sent to the hydraulic actuator. Some output is fed back through the stabilizer section to keep the system from overreacting.

The schematic representation of the control box (fig. 5-7) is a simplification of the actual amplifier and is useful in describing its operation.

If the speed setting potentiometer is adjusted to increase speed, it causes a voltage signal change at the base of transistor Q1 in the positive direction. This increases the conduction of transistor Q1. This causes increased current through resistor R1 and a drop in potential at point A (base of transistor Q4). The effect on transistor Q4 is to cause an increase in current through resistor R5. The increased voltage drop across resistor R5 raises the potential at point B. An increase in potential at point B (base of transistors Q5 and Q6) causes Q5 to conduct more and Q6 to conduct less. This increases the potential at point C (base of transistors Q7 and Q8). This increase causes Q7 to conduct more and Q8 to conduct less which increases the potential at point D. An increase in potential at point D causes current to flow through the actuator coil in the direction to move the actuator pilot valve plunger in the increase steam direction. This steam increase causes the turbine to increase speed. The negative speed signal increase counteracts the previous positive speed signal increase. A new steady-state condition of essentially zero voltage is then reached both at the summing point and the actuator.



111.156

Figure 5-8.—Voltage relationships.

To further explain the function of the amplifier and its stabilizing feedback network, refer to the voltage waveforms of figure 5-8 as well as the schematic of figure 5-7.

Assume that a step input voltage signal is applied to the summing point of the amplifier, as shown on curve 1 (fig. 5-8). If the feedback circuit is disconnected at point I (fig. 5-7), the output voltage for this condition (without feedback and stabilization) will be very high. This is shown in curve 2 (fig. 5-8). This will cause the turbine to hunt excessively. The gain (output voltage divided by input voltage) is very high in this condition. Assume that the feedback network is reconnected at point I, and the stabilizing network is disconnected at point J. In this case the output signal from point D is fed through the stability potentiometer to the base of transistor Q2 (point E). This reduces the amplifier gain. In response to the step input of curve 1, an output voltage for this condition (feedback connected but without stabilization) is obtained (curve 3, fig. 5-8).

Earlier, we stated that the output voltage at point D and at the actuator increases in response to an increased positive potential at the summing point of the amplifiers which causes the turbine speed to increase. Resetting of the amplifier is now achieved by the increase in potential across the actuator which is applied to the base of transistor Q2, causing Q2 to conduct a greater amount. This increases the voltage drop across resistor R3. The potential at point F (the emitter of input transistor Q1), is raised, causing Q1 to conduct less. This reduces the amount of voltage drop otherwise experienced at point A. In turn, the amount of conductance of transistor Q4 is reduced. Consequently, there is less voltage change at point B. Adjustment of P1 is used to increase the potential at point E and reduces the amplifier gain. Transistor Q2 conducts a greater amount thereby reducing the potential at point G. This is because of a greater voltage drop across resistor R2. The potential at G (applied to the base of transistor Q3) causes Q3 to conduct more with a greater voltage drop across resistor R4. Consequently, the lower potential at point H (the emitter of transistor Q4) causes it to conduct less. This results in a smaller increase in potential at point B or a gain reduction.

The stabilization signal is obtained through the use of a capacitor. With capacitor C1 disconnected at point J (fig. 5-7), the negative feedback effect reduces the gain (curve 3, fig. 5-8). When the circuit is reconnected at point J, the capacitor temporarily diverts some of the feedback signal away from point E during the charging period of the capacitor.

In response to the input voltage (curve 1, fig. 5-8), the initial output voltage of the amplifier goes to a high level (curve 4, fig. 5-8) at the first instant the signal is applied and the

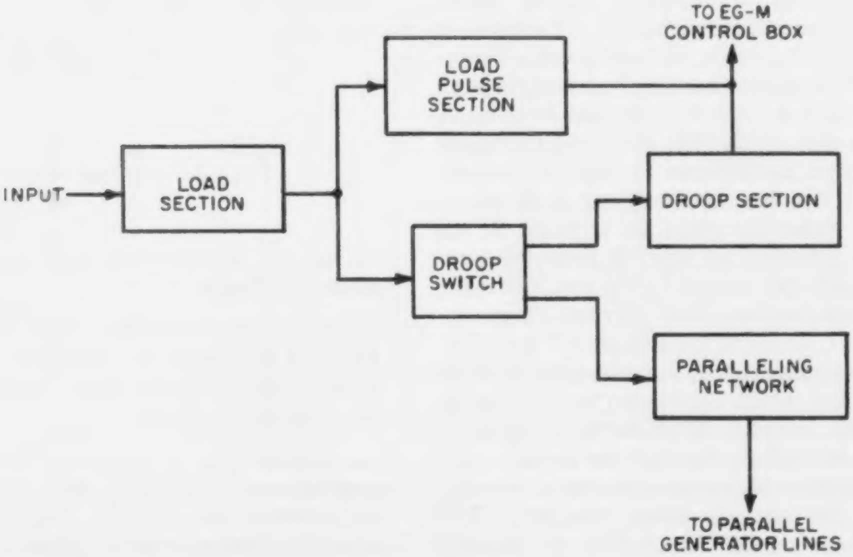


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Figure 5-9.—Load signal box, block diagram.

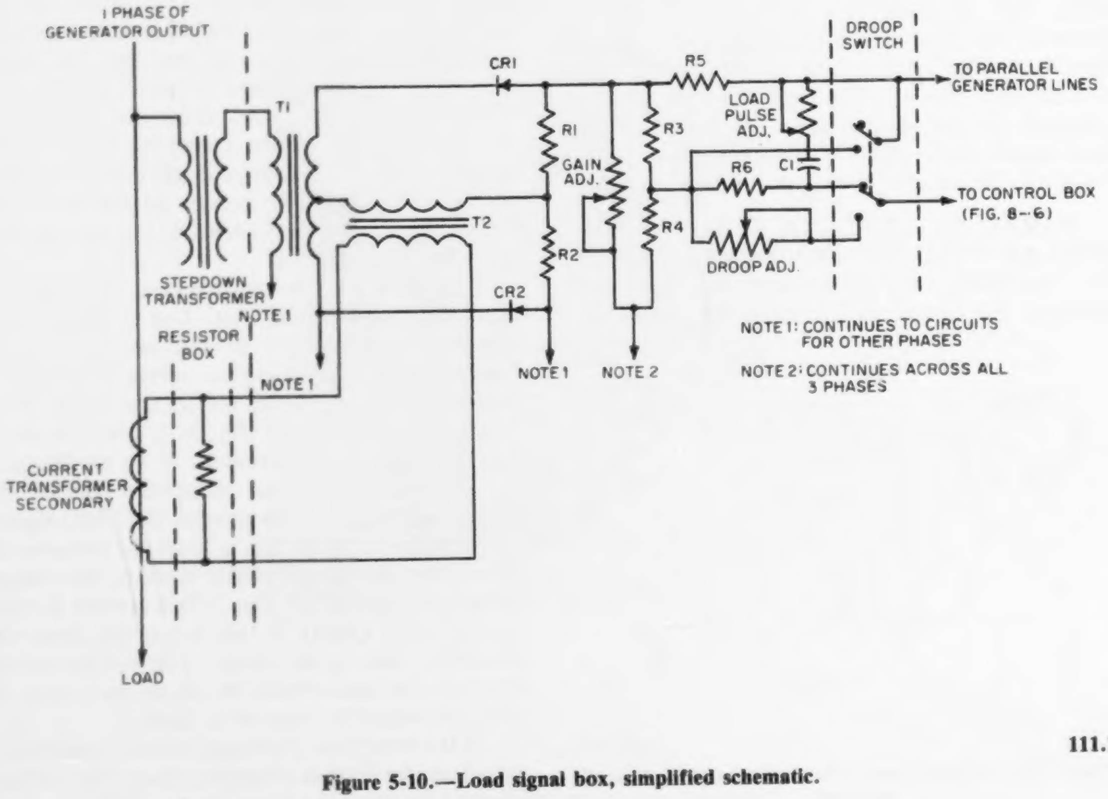
feedback signal is varied. As the capacitor charges, the voltage comes down on the curved portion of the line. It levels off at approximately the same level as curve 3 when a steady-state condition is reached. The shape of curve 4 is determined by an RC time constant. R is adjustable by the stability potentiometer. The normal response of the amplifier to an open loop test (fig. 5-8) produces an output voltage waveform characteristic of curve 4. This is in response to the input voltage of curve 1.

Load Signal Box

The load signal box enables the governor system to respond to generator load changes, as well as to speed changes. Load changes are detected and responded to before they appear as turbine speed changes. This minimizes speed change transients.

The load signal box (fig. 5-9) converts a three-phase input signal (from the generator leads through the resistor box) to a positive d.c. voltage. This voltage is proportional to the kW load on the generator. The voltage is applied to the load pulse section and the paralleling network. When operated with dissimilar governors, the droop and load pulse sections are used. The droop switch determines the operating mode for which the system is set up.

SINGLE GENERATOR OPERATION.— Look at the simplified schematic of the load signal box in figure 5-10. Input signals for the load signal box are taken from the secondary of the generator current transformers and developed in the resistor box. The resistor box contains three resistors (one for each phase). The voltage input is applied to transformer T2 and compared to the generator voltage phase. This is taken from the generator line, stepped down, and


I PHASE OF GENERATOR OUTPUT
T1
CR1
R5
DROOP SWITCH
TO PARALLEL GENERATOR LINES
LOAD PULSE ADJ.
R1
GAIN ADJ.
R3
R6
C1
TO CONTROL BOX (FIG. 8-6)
T2
R4
R2
DROOP ADJ.
STEPDOWN TRANSFORMER
NOTE 1
CR2
RESISTOR BOX
NOTE 1
NOTE 1
NOTE 2
NOTE 1: CONTINUES TO CIRCUITS FOR OTHER PHASES
NOTE 2: CONTINUES ACROSS ALL 3 PHASES
CURRENT TRANSFORMER SECONDARY
LOAD

111.158

Figure 5-10.—Load signal box, simplified schematic.

applied to transformer T1. If both voltages are in phase, they will cancel. Therefore, no output will appear. If they are out of phase (the load is changing), a voltage in proportion to the generator load will be rectified by CR1 and CR2. Although only one phase is shown in figure 5-10, each phase is compared. The comparison circuitry is identical to that shown.

The amplitude of the signal can be varied by the GAIN ADJ. potentiometer. A variable pulse output is developed by the charge/discharge time of C1 through the LOAD PULSE ADJ. potentiometer.

The load pulse signal is initially maximum and gradually decreases to zero. Figure 5-11 represents load pulse signals in response to load changes. The signal is of the proper polarity to set the steam valve in the right direction to compensate for the change. The output signal is applied to the summing point in the EG-M control box (fig. 5-7).

PARALLEL OPERATION WITH OTHER EG GOVERNOR SYSTEMS.—When the load signal box is used with other EG governor systems, the operation is the same as for single operation (fig. 5-10) except for a closed circuit breaker (not shown). The closed circuit breaker connects the paralleling lines. This enables the load signal box to provide the same signal information to the control box of all the parallel units.

PARALLEL OPERATION WITH DISSIMILAR TYPE GOVERNOR SYSTEMS.—For operation with dissimilar type governor systems, the droop switch must be turned on (down position in fig. 5-10). This shorts out the paralleling lines so that the parallel units are effectively not connected to the load signal box. The signal to the control box is fed by the DROOP ADJ. potentiometer. This adjustment compensates for differences in generator ratings and the reactive load carried by them.

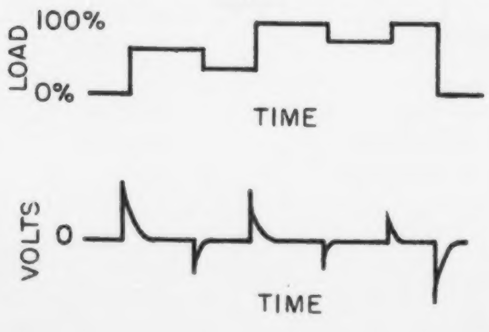


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Figure 5-11.—Comparison of load pulse signals to load changes.

MAINTENANCE

Governor faults are usually revealed in turbine speed variations. However, a check of the system is necessary since not all speed variations are caused by a faulty governor.

Check first to determine that the changes are not a transient result of load changes. If the load is constant, hold an inspection to see that the operating linkage between the hydraulic actuator and the turbine is free from binding or lost motions. If the linkage is proper, check the voltage regulator for proper operation. If these checks do not reveal the cause of the speed variation, the governor is probably faulty.

In troubleshooting the governor system, first check the voltage across the input to the hydraulic actuator. This should be done with the system running on speed and set for single operation. If the voltage is not correct (+0.5 volts d.c. to −0.5 volts d.c.) and cannot be set within range by the centering screw in the actuator, or if the voltage fluctuates more than +0.25 volts d.c. and cannot be stilled by the GAIN ADJ. or the STAB. ADJ., the control box may be defective.

To bench test the control box, disconnect it from the load signal box. Use a three-phase power supply instead of the normal supply. Instead of the speed signal, apply a frequency oscillator output signal set to the rated speed frequency of the PMG (fig. 5-7). Use a resistive load instead of the actuator. If an oscillator is not available, you can manually control the turbine-generator set to provide the PMG signal.

The converter section is working properly if, after removing the amplifier section, the voltage at the collector of Q2 (fig. 5-7) is correct (6 volts d.c. at rated speed). If this is correct, place the amplifier back in the circuit. The voltage across the resistive load should be about zero volts. If not, the amplifier section is faulty.

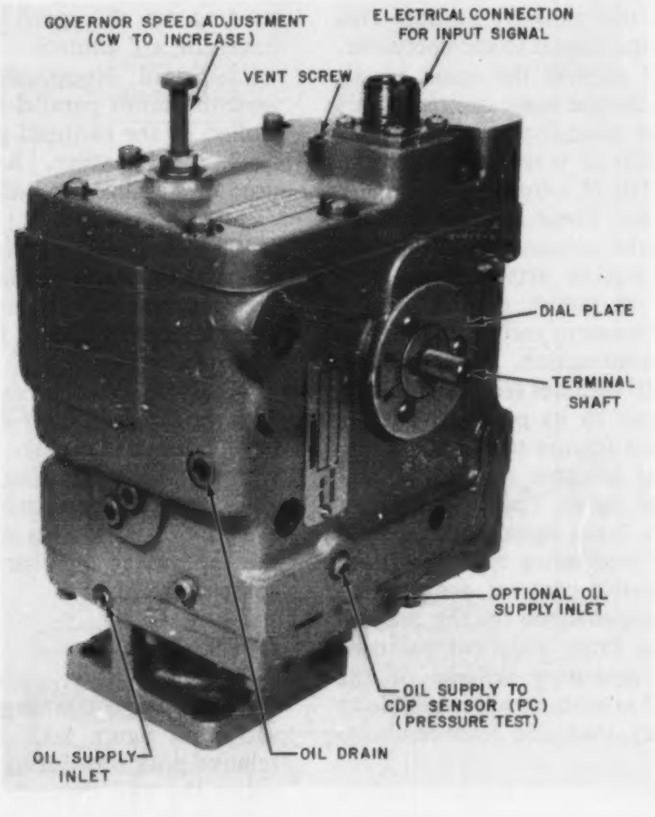
If the trouble is a change in unit steady-state speed as the load is changed, check the voltage across the actuator input under different load conditions. If the voltage is the same at both loads, the control box may be defective. If the voltages differ by more than 0.2 volts d.c., the actuator is probably faulty.

The source of most troubles in the hydraulic actuator or valve operator is dirty oil. Grit and other impurities may be introduced into the system with the oil or may form when the oil begins to break down (oxidize) or become sludge. The moving parts within the actuator and valve operator are continually lubricated by the oil within the units. Thus, grit and other impurities can cause excessive wear of valves, pistons, and plunger. This can cause these parts to stick or freeze in their bores.

For the remainder of this chapter, we will discuss the EGB-2P governor/actuator and the 2301 load and speed-sensing control, which are used to form another system.

EGB-2P GOVERNOR/ACTUATOR

The EGB-2P (fig. 5-12) is a proportional actuator with a ballhead backup governor. The


GOVERNOR SPEED ADJUSTMENT (CW TO INCREASE)
ELECTRICAL CONNECTION FOR INPUT SIGNAL
VENT SCREW
DIAL PLATE
TERMINAL SHAFT
OPTIONAL OIL SUPPLY INLET
OIL SUPPLY TO CDP SENSOR (PC) (PRESSURE TEST)
OIL SUPPLY INLET
OIL DRAIN

111.202X

Figure 5-12.—EGB-2P governor actuator.

proportional actuator's terminal (output) shaft position is directly proportional to the magnitude of the output signal from the electronic control unit. The uses and functions of a proportional actuator are different and distinct from integrating types of EG actuators. To have a correct governoring system, you must use the EGB-2P actuator with the 2301 or similar integrating electronic control. By comparison, the EGB-2P is an integrating actuator with the companion EG-A control box being basically a proportional amplifier.

Proportional actuators can be used in the same type of service as other actuator models. They are particularly well suited to engines operating in tandem to drive a common load. In such installations, one electric control can be used for two or more proportional actuators wired in series with the control's output. This furnishes the same input signal to each actuator. Since each actuator receives the same signal, their output shafts take the same position. This gives each engine the same fuel.

Externally the EGB-2P is similar in size and appearance to the EGB-2C actuator. Internally, each has two sections. These are the ballhead governor and electric actuator section. The ballhead governor section acts as a backup governor in event of failure of the electric control. The electric actuator section is different in function and construction. The actuator section of the EGB-2P includes feedback linkage from its power piston to its pilot valve. This gives the proportional feature to the actuator.

The proportional actuator requires a continuous electric input signal. This is in contrast to the nominally zero input signal under steady-state conditions for integrating type actuators. Woodward 2301 electric controls are used to furnish the control input signal for the proportional actuator. The exact 2301 control used depends upon the operating scheme of the installation. Control assemblies are available to sense speed, frequency, load, and other combinations.

The essential element of the actuator section of the EG-B2P is an electrohydraulic transducer. This transducer directs pressure oil to and from the power piston to actuate the fuel or steam control mechanism. The transducer consists of a solenoid attached to the pilot valve plunger. This controls oil flow to and from the power piston. The solenoid responds to the given output of the electric control. This moves the pilot valve plunger down, directing oil to the power piston. Through connecting linkage, the power piston moves the terminal shaft of the actuator. The engine or turbine fuel linkage attaches to the actuator terminal shaft.

Strict linearity of terminal shaft travel versus load is not required. However, the linkage should be arranged to give the same degree of linearity given conventional speed-sensing governors.

The centrifugal governor section has three operating adjustments. Once set, these adjustments do not usually require further adjustment. These settings are listed below.

1. Speed setting. An external adjustment used to set the speed at which the ballhead governor will control.
2. Speed droop. An internal adjustment used to permit parallel operation of units controlled by the ballhead governor.
3. Needle valve. An external adjustment used to stabilize the ballhead governor.

The actuator section of the EGB-2P has no external operating adjustments. The actuator uses oil from the engine lubricating system or from a separate sump. It does not have a self-contained sump.

EGB-2P governor/actuators are available with the terminal shaft extending from either or both sides of the case. They can be furnished with the speed adjusting shaft (for the ballhead governor section) extending on either side. However, most units use a speed adjusting screw in the top cover. They omit the speed adjusting shaft entirely.

OPERATION

The schematic arrangement of the EGB-2P is shown in figure 5-13. The parts are in their relative positions during normal operation. Oil enters the unit through either of the two inlet holes in the side of the base. The oil passes from the suction to the pressure side of the pump. After filling the oil passages, the pump builds up the oil pressure. When the pressure is high enough to overcome the relief valve spring force,

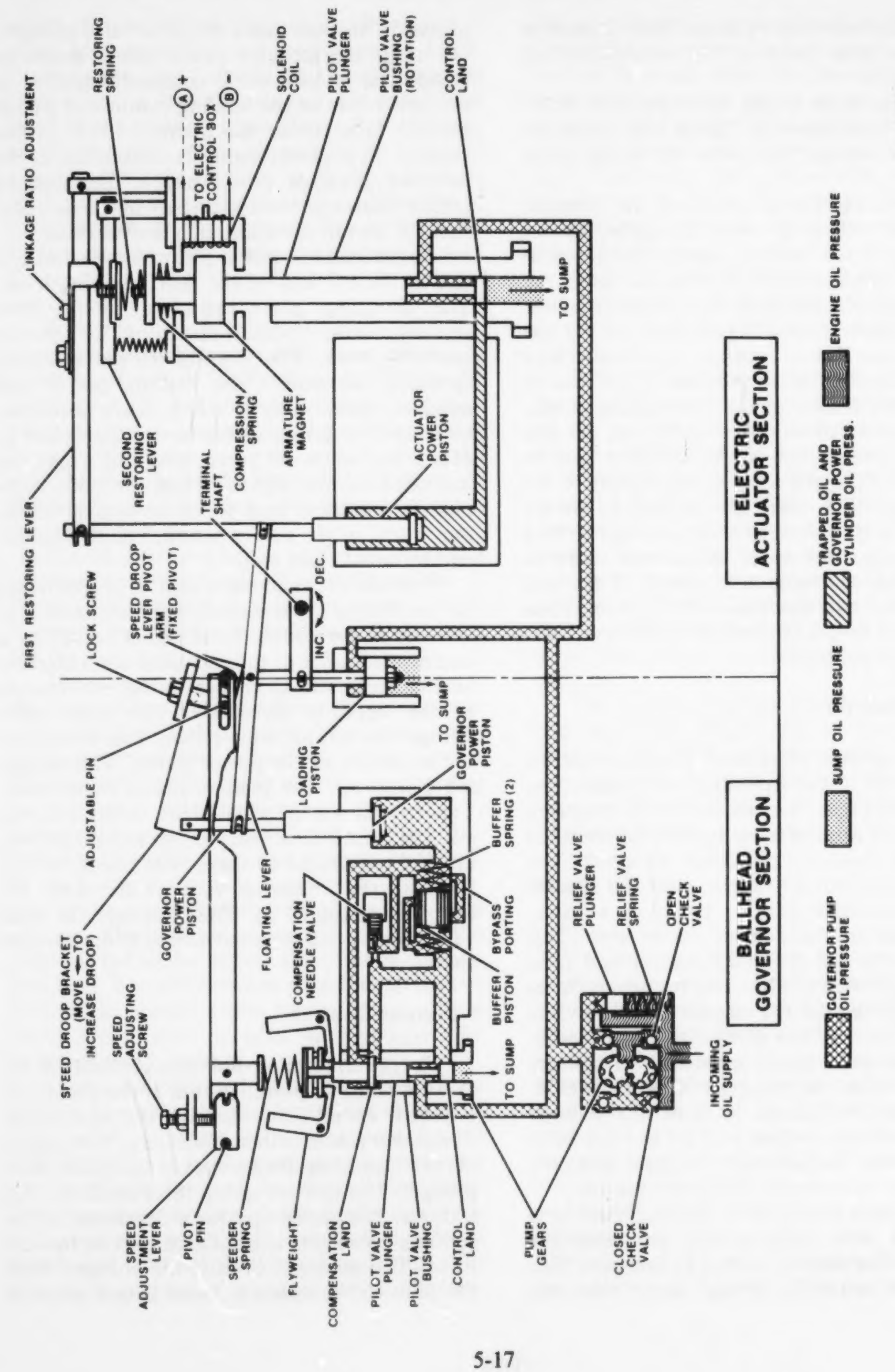

SPEED ADJUSTMENT LEVER
PIVOT PIN
SPEEDER SPRING
FLYWEIGHT
COMPENSATION LAND
PILOT VALVE PLUNGER
PILOT VALVE BUSHING
CONTROL LAND
PUMP GEARS
CLOSED CHECK VALVE
SPEED ADJUSTING SCREW
SPEED DROOP BRACKET (MOVE ← TO INCREASE DROOP)
GOVERNOR POWER PISTON
FLOATING LEVER
COMPENSATION NEEDLE VALVE
BUFFER PISTON
BYPASS PORTING
BUFFER SPRING (2)
TO SUMP
ADJUSTABLE PIN
LOADING PISTON
GOVERNOR POWER PISTON
TO SUMP
LOCK SCREW
SPEED DROOP LEVER PIVOT ARM (FIXED PIVOT)
INC
DEC.
TERMINAL SHAFT
FIRST RESTORING LEVER
SECOND RESTORING LEVER
COMPRESSION SPRING
ARMATURE MAGNET
ACTUATOR POWER PISTON
LINKAGE RATIO ADJUSTMENT
RESTORING SPRING
TO ELECTRIC CONTROL BOX
Ⓐ +
Ⓑ −
SOLENOID COIL
PILOT VALVE PLUNGER
PILOT VALVE BUSHING (ROTATION)
CONTROL LAND
TO SUMP
RELIEF VALVE PLUNGER
RELIEF VALVE SPRING
OPEN CHECK VALVE
INCOMING OIL SUPPLY
BALLHEAD GOVERNOR SECTION
ELECTRIC ACTUATOR SECTION
GOVERNOR PUMP OIL PRESSURE
SUMP OIL PRESSURE
TRAPPED OIL AND GOVERNOR POWER CYLINDER OIL PRESS.
ENGINE OIL PRESSURE
111.203X

Figure 5-13.—Schematic diagram EGB-2P governor/actuator.

it pushes the relief valve plunger back to uncover the bypass hole. Oil then recirculates through the pump.

Rotation of the pump in the opposite direction from that shown in figure 5-13 closes the open check valves and opens the closed check valves.

The loading piston positions the terminal shaft. Constant oil pressure is applied to the upper side of the loading piston. This tends to move it in the decrease fuel direction. Either the governor power piston or the actuator power piston can move the loading piston in the increase fuel direction. This is because the effective area on which the control oil pressure acts is greater on the power piston than on the loading piston.

In the event of an electrical failure, the unit goes to minimum fuel. If the actuator goes to minimum fuel, apply a 9-volt d.c. supply to the transducer. This takes the actuator toward maximum fuel. This allows the governor to take control. Adjust the speed adjustment screw to give the desired steady-state speed. If the unit has a manual override knob on the cover, push it down and turn it to the right. This locks out the actuator control.

Actuator Control

The actuator's pilot valve plunger controls the flow of oil to and from its power piston. The pilot valve plunger is connected to an armature magnet. This magnet is spring-suspended in the field of a two-coil polarized solenoid. The output signal from the electric control is applied to the polarized coil. This produces a force, proportional to the current in the coil. This tends to force the armature magnet and pilot valve plunger down. The restoring spring force tends always to raise the magnet and pilot valve plunger. When the unit is running under steady-state conditions, these opposing forces are equal. The pilot valve plunger is then centered. This means the control land of the plunger exactly covers the control port in the pilot valve bushing. With the pilot valve plunger centered, no oil flows to or from the power piston.

An increase in engine or turbine speed or a decrease in unit speed setting will cause the signal from the electric control to decrease. This makes the restoring spring force relatively greater. This then raises the pilot valve plunger. Oil under the actuator power piston drains to sump. The oil pressure is constantly applied to the upper side of the loading piston and power piston. This forces the pistons down as the floating lever pivots about its connection to the ballhead governor power piston. The loading piston rotates the terminal shaft in the decrease fuel (or steam) direction as it moves down.

As the actuator power piston moves down, it lowers the left end of the first restoring lever. The clamping plate, attached to the first restoring lever, pushes down on the second restoring lever. The loading on the restoring spring is increased. The loading piston and actuator power piston move down until the increase in restoring spring force is sufficient to offset the increased force, resulting from the increased electric signal. When the pilot valve plunger is pushed back to its centered position, movement of the power piston, loading piston, and terminal shaft stop.

Position of the actuator shaft is proportional to the electric input signal to the actuator. An increase in the electric input signal caused by a decrease in engine or turbine speed or an increase in unit speed setting creates similar movements in the opposite directions. The pilot valve plunger lowers, allowing pressure oil to flow to the underside of the power piston. This pushes the piston up. The loading piston then raises. This rotates the terminal shaft in the increase fuel (or steam) direction. At the same time, the upward movement of the power piston, acting through the restoring levers, decreases the restoring spring force. This recenters the pilot valve plunger and stops movement of the terminal shaft.

Governor Control

The governor pilot valve plunger controls the flow of oil to its power piston. If the plunger is centered, no oil flows through the pilot valve. The power piston is then stationary. The greater of two opposing forces moves the pilot valve plunger. The speeder spring force tends to push it down. The centrifugal force developed by the rotating flyweights is translated into an upward force. This attempts to raise the plunger. With the pilot valve centered, there is one speed at which the centrifugal force of the flyweights is equal and opposite to the speeder spring force.

With the speed setting of the governor set slightly higher than the actuator, the centrifugal force of the rotating flyweights is not sufficient to lift the pilot valve plunger to its centered position. With the actuator controlling, pressure oil is continually directed to the underside of the governor power piston. This holds it up against its stop. This is why the power piston of the governor is against its stop when the actuator is controlling.

With the unit running on speed with the governor controlling, the pilot valve plunger is centered. If a load is added to the engine, the engine and governor speeds decrease. The pilot valve plunger is lowered by the speeder spring force. This force is now greater than the centrifugal force of the flyweights. Pressure oil flows to the buffer piston. This moves it towards the power piston.

The oil displaced by the buffer piston forces the power piston upward. The loading piston is raised. The terminal shaft is then rotated in the direction to provide the additional fuel needed for the new load.

The movement of the buffer piston towards the power piston partially relieves the compression of the left-hand buffer spring. This increases the compression of the right-hand buffer spring. The force of the right-hand buffer spring tending to resist this movement results in a slightly higher oil pressure on the left side of the buffer piston than on the right. The pressure on the left of the buffer piston is transmitted to the underside of the compensation land of the pilot valve plunger. The pressure on the right of the buffer piston is fed to the upper side of the compensation land. The difference in pressures on the two sides of the compensation land produces a force which acts to push the pilot valve plunger back to its centered position.

When the terminal shaft has rotated far enough to satisfy the new fuel requirement, the pilot valve recenters. This is caused by the differential force on the compensation land plus the centrifugal force of the rotating flyweights. This happens even though the engine speed has not returned completely to normal. Power piston and terminal shaft movement stops. The continued increase of speed to normal increases the centrifugal force developed by the rotating flyweights. However, this increase of speed to normal does not cause the flyweights to lift the pilot valve plunger above center. Oil leakage through the needle valve orifice equalizes the pressure above and below the compensation land. This is at a rate proportional to the return of the engine speed to normal. Then, as the centrifugal force increases, the compensating force decreases.

With the pressures above and below the compensation land equalized, the buffer springs return the buffer piston to its normal centered position.

When engine load decreases, the resultant increase in governor speed causes the flyweights to move outward. This raises the pilot valve plunger. With the pilot valve plunger raised, the area to the left of the buffer piston is connected to sump. The loading piston is continually urged downward by oil pressure from the governor pump. The piston moves down and forces the governor power piston down. The movement reduces the fuel to meet the new requirement. Again, differential pressure across the compensation land helps to recenter the pilot valve plunger.

The speed at which the governor controls the engine is determined by the loading or compression of the speeder spring. This spring opposes the centrifugal force of the flyweights. The standard EGB-2P has a speed adjusting screw in the top cover, as shown in figure 5-13.

Speed Droop

Speed droop is used in governors to divide and balance load between engines or turbines driving the same common load or driving generators paralleled in an electrical system. Speed droop is defined as the decrease in speed taking place when the governor output shaft moves from the minimum to the maximum position in response to a load increase. It is expressed as a percentage of rated speed. Speed droop is provided in the EGB-2P through linkage which varies the loading on the speeder spring as a function of the power piston position. The change in speeder spring force for a given movement of the power piston is determined by the position of the adjustable pin in the linkage between the power piston and speeder spring. If the pin is on the same centerline as the speed droop lever pivot arm, there is no change in speeder spring force as the power piston moves. The governor then operates as an isochronous (constant speed) control. The further the adjustable pin is moved away from the pivot arm centerline, the greater the change in compression of the speeder spring for a given power piston movement.

With the unit operating under the electric control, the speed droop feature is, in effect, inoperative. During such operation, the governor power piston remains in the maximum position for all engine or turbine loads (except possibly momentarily during transients). Therefore, the speed droop linkage does not alter the speeder spring compression when the actuator is controlling.

MAINTENANCE

As stated earlier, the source of most troubles in any hydraulic actuator or governor stems from dirty oil. Valves, pistons, and plungers will stick and even freeze in their bores, due to excessive wear caused by grit and impurities in the oil. If this is the case, erratic operation and poor response can be corrected by flushing the unit with fuel oil or kerosene. The use of commercial solvents is not recommended as they may damage seals or gaskets.

If the speed variation of the unit is erratic but small, excessive backlash or a tight meshing of the gears driving the unit may be the cause. If the speed variation is erratic and large and cannot be corrected by adjustments, repair or replace the unit.

2301 ELECTRIC GOVERNOR

The 2301 electric control (fig. 5-14) is a combination of four modules mounted on a single control panel. The control panel is the controlling portion of the 2301 system. The system is comprised of the 2301 electric control (described here), a magnetic pickup, current and potential transformers, and a hydraulic actuator. The system can provide isochronous (constant speed) or droop (speed regulation) operation for prime movers such as diesel or gas engines and steam or gas turbines.

Isochronous operation provides constant engine speed for single unit operation or when several units are paralleled on an isolated bus. Droop operation allows paralleling of two or more units and provides speed regulation as a function of generator load.

Two engines driving a common load can be operated from one 2301 electric control by connecting the actuators in series. Since each actuator receives the same input signal, each engine receives the same amount of fuel.

The output of the 2301 electric control provides a unidirectional continuous voltage level to the actuator which provides the desired speed and load relationship called for by the input signals to the control panel. This type of output signal requires a proportional actuator. The proportional actuator contains a servo piston which operates in proportion to the input voltage applied.

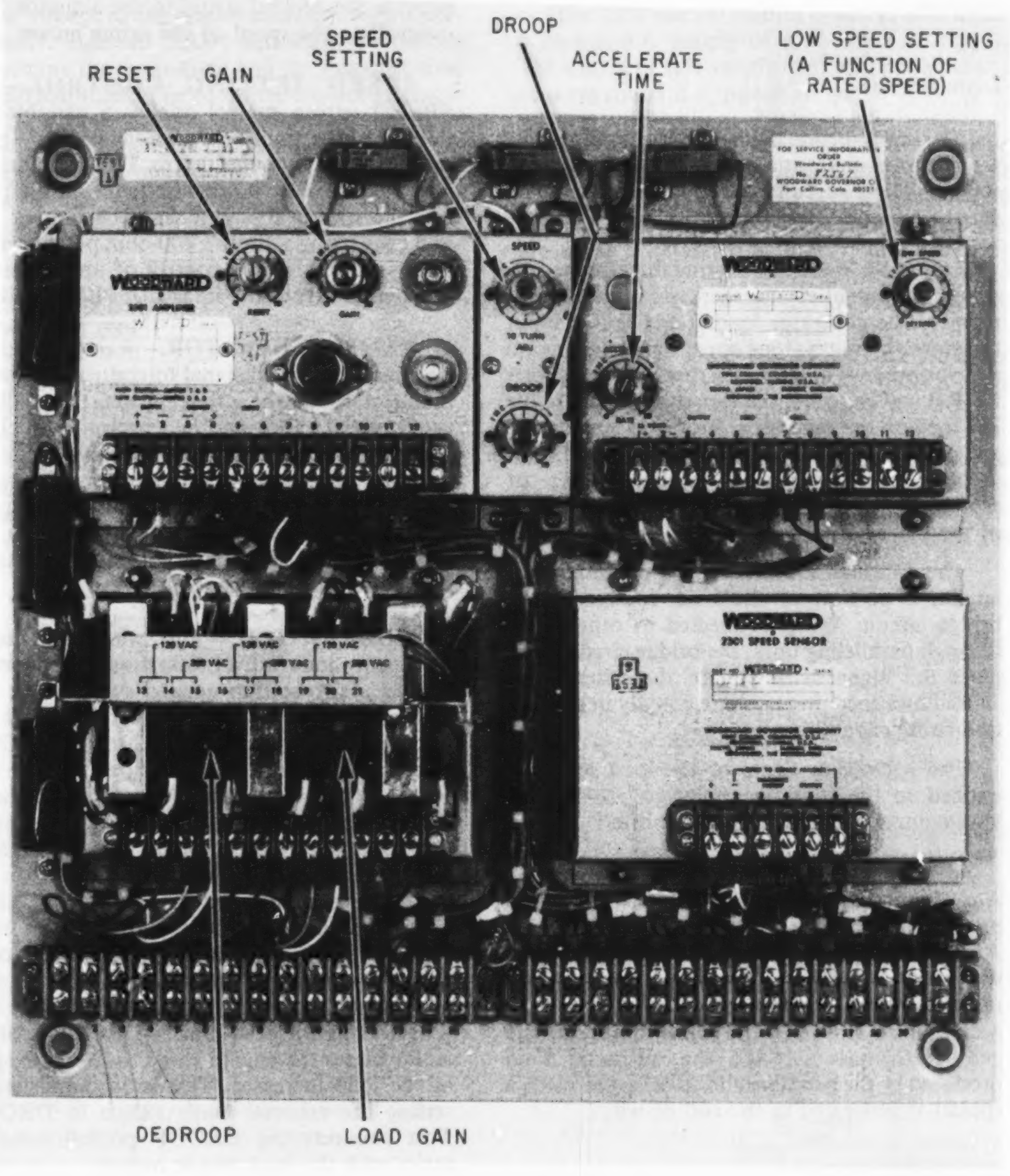
The electric control also contains a ramp generator module which controls the rate of acceleration during initial start-up. After the unit reaches set speed, further control action from the ramp generator is blocked.

The load sensor provides either parallel isochronous load sharing or droop operation for the unit.

As with any governor, the engine should be equipped with a separate overspeed device. This prevents runaway if a failure should render the governor inoperative.

OPERATION

The 2301 system is programmed to maintain preset speed- and load-sensing levels. These are in proportion to the capacity of the unit being controlled. For purposes of explanation, the


RESET
GAIN
SPEED SETTING
DROOP
ACCELERATE TIME
LOW SPEED SETTING (A FUNCTION OF RATED SPEED)
WOODWARD
2301 AMPLIFIER
WOODWARD
2301 SPEED SENSOR
120 VAC
240 VAC
DEDROOP
LOAD GAIN

111.204X

Figure 5-14.—2301 load- and speed-sensing control.

system is divided into two sections: input and control (see fig. 5-15, a foldout at the end of this chapter).

Input Section

The input section consists of the load sensor, the external magnetic pickup, and the speed sensor. These circuits detect and process the speed and load input signals.

LOAD SENSOR.—External three-phase current and potential transformers are used to monitor the generator load. Load sensor input transformers process the current signals (expressed as a voltage level developed across burden resistors R1-R3) and the potential signals to compute the kW load on the generator. Rectifiers convert the a.c. voltage from the transformers to d.c. A voltage adder circuit adds the d.c. voltage of each phase and provides a signal representative of the kW load.

The internal LOAD GAIN potentiometer applies a portion of the load voltage to the bridge circuit. When connected to other units through paralleling lines, the bridge circuit compares this signal with that of the other units. This allows each unit to share equally in proportion to its capability.

The correcting signal of the load sensor is applied to the summing point to provide the load control function to the amplifier.

MAGNETIC PICKUP/SPEED SENSOR.—A.c. input pulses from a magnetic pickup provide the speed input signal to speed sensor A4. The magnetic pickup consists of a coil of wire wound around a permanent magnet. This magnet pickup is mounted close to a toothed gear which is driven by the prime mover. As the gear teeth pass through the magnetic field produced by the permanent magnet, a step voltage (pulse) is generated in the coil of wire.

Control Section

The control section consists of the SPEED setting control, the ramp generator, an external mode switch, the DROOP control, and the amplifier module. These circuits combine to provide the control signal to the actuator, thus controlling the speed of the prime mover.

SPEED SETTING CONTROL.—The SPEED setting control applies a variable d.c. voltage to the amplifier summing point. When a jumper wire is connected to TB1 terminals 20 and 21, the SPEED potentiometer on the panel sets the speed. Disconnecting the jumper wire and connecting a 10-turn 100-ohm potentiometer allows external speed control of approximately ±4 percent from the internal SPEED setting.

RAMP GENERATOR.—Ramp generator A3 biases the speed signal to control the rate of acceleration of the prime mover from idle to rated speed. Closing the external switch or contacts connected to TB1 terminals 14 and 15 starts the acceleration ramp. Opening the switch or contacts returns the unit to idle speed. Front-panel screwdriver adjustments set the LOW SPEED SETTING and ACCELERATE RATE of the ramp generator.

MODE SWITCH.—This switch selects either the isochronous or the droop mode of operation. This is a two-section ganged switch. The first section (a speed switch) either connects the paralleling lines to the load sensor (TB1-10) for isochronous operation, or it unbalances the load sensor bridge by shunting one leg to common (TB1-11). The second section (also a speed switch) connects the load sensor output (A2TB1-5) for isochronous or droop operation. In the isochronous mode, the load sensor output is connected directly to the summing point. In the DROOP mode, the output is connected to the DROOP control potentiometer.

DROOP CONTROL.—DROOP control A5R1 biases the engine speed to decrease speed as the load increases. This is accomplished by setting the external mode switch to DROOP. This connects the DROOP potentiometer in series with the load sensor output.

AMPLIFIER.—The output signals from the load sensor, the speed sensor, the SPEED setting potentiometer, and the ramp generator are applied to the summing point input of amplifier A1. Amplifier A1 amplifies the resultant input voltage to increase or decrease fuel proportionally. Internal GAIN and RESET controls determine the magnitude and the response time of the amplifier. The complete control system is a closed loop (sensors, amplifier, actuator, fuel flow, prime mover speed, sensors), and the purpose is to match the electronic response time to the system response time for stable operation.

DETAILED CIRCUIT DESCRIPTION

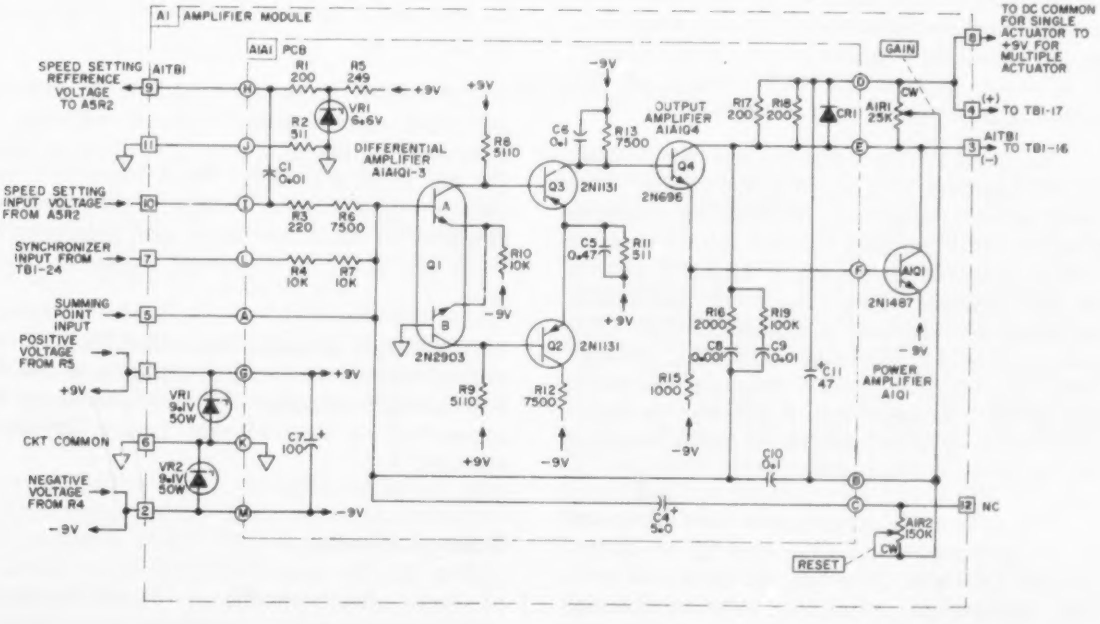
The following sections provide a more detailed description of the 2301 electric control circuitry. These detailed descriptions are keyed to the individual module schematics. Block schematic diagram, figure 5-15, shows all the modules in relationship to one another including inputs and outputs.

Input Voltage Distribution

The 2301 electric control operates with either a 24-volt d.c. supply or a 32-volt d.c. supply. The source of this supply can be either a battery or a regulated d.c. power supply.

Resistors R4 and R5 (see block schematic diagram figure 5-15) are current-limiting resistors for zener voltage regulators A1VR1 and A1VR2 (see amplifier schematic figure 5-16). When you are using a 24-volt d.c. supply, this operating voltage is applied to TB1 terminals 12 (+) and 13 (−) (fig. 5-15). When you are using a 32-volt d.c. supply, operating voltage is applied to TB1 terminals 25 (+) and 13 (−). Resistor R6 drops the +32-volt to +24-volt d.c. before being applied to current-limiting resistor R5.

Protection diode CR1, mounted on the panel, is in series with the negative voltage supply lead (common to both the 24-volt and 32-volt d.c. supplies). The diode protects the


A1 AMPLIFIER MODULE
A1A1 PCB
A1TB1
SPEED SETTING REFERENCE VOLTAGE TO A5R2
SPEED SETTING INPUT VOLTAGE FROM A5R2
SYNCHRONIZER INPUT FROM TB1-24
SUMMING POINT INPUT
POSITIVE VOLTAGE FROM R5
+9V
CKT COMMON
NEGATIVE VOLTAGE FROM R4
−9V
9
11
10
7
5
1
6
2
H
J
I
L
A
G
K
M
R1 200
R5 249
VR1 6.6V
R2 511
C1 0.01
R3 220
R6 7500
R4 10K
R7 10K
VR1 9.1V 50W
VR2 9.1V 50W
C7 100
DIFFERENTIAL AMPLIFIER A1A1Q1-3
Q1
A
B
2N2903
R8 5110
R9 5110
R10 10K
R12 7500
Q2 2N1131
Q3 2N1131
C5 0.47
R11 511
C6 0.1
R13 7500
OUTPUT AMPLIFIER A1A1Q4
Q4 2N696
R15 1000
R16 2000
R19 100K
C8 0.001
C9 0.01
C10 0.1
C11 47
R17 200
R18 200
CR1
A1R1 25K
CW
GAIN
D
E
F
B
C
A1Q1 2N1487
POWER AMPLIFIER A1Q1
C4 5.0
A1R2 150K
RESET
TO DC COMMON FOR SINGLE ACTUATOR TO +9V FOR MULTIPLE ACTUATOR
8
4
(+) TO TB1-17
3
A1TB1 TO TB1-16 (−)
12
NC

111.206X

Figure 5-16.—Amplifier schematic.

circuitry by reverse biasing if the input voltage polarity should ever be reversed.

Voltage regulators A1VR1 and A1VR2 regulate the 24 volt d.c. to +9 and −9 volt d.c. with respect to center tap common (A1TB1 terminal 6). This +9 and −9 volt d.c. is the regulated supply voltage for the 2301 electric control system.

Speed Setting Reference Voltage

Since the speed setting input voltage determines the speed of the prime mover, a stable reference voltage is necessary for stable speed control. Zener diode A1A1VR1 provides a stable 6.6 volt d.c. at TB1 terminal 21 (fig. 5-15) for the speed setting control.

Amplifier

Input signals from the various input and control circuits (fig. 5-16) are algebraically added together at the summing point input to the amplifier (A1TB1 terminal 5). The steady-state condition of the closed loop (sensors, amplifier, actuator, fuel flow, prime mover speed, sensors) is a value approaching null voltage at the summing point input to the amplifier.

The speed setting input voltage (positive) at A1TB1 terminal 10 is algebraically added to the speed sensor voltage (negative) at the summing point (A1TB1 terminal 5). A resultant positive voltage causes input transistor A1A1Q1 to turn on and conduct. This causes the differential amplifier to become unbalanced. The Q1A emitter potential decreases conduction through Q1B. The Q1B collector potential decreases conduction through Q2. Collector potential from Q1A forward biases A1A1Q3, causing increased conduction through Q3.

The differential amplifier is now set to call for an increase in fuel. Q1A and Q3 are turned on, and Q1B and Q2 are at the threshold level. The differential amplifier remains in this configuration until the speed sensor input nulls out the speed setting voltage level. At that time the differential amplifier becomes balanced.

As conduction increases through A1A1Q3, the Q3 collector potential biases output amplifier A1A1Q4 for increased conduction. The Q4 emitter potential forward biases power amplifier A1Q1, turning A1Q1 on. Power amplifier A1Q1 saturates to clamp −9 volt to A1TB1 terminal 3 and supply the current required by the actuator coil.

System stability is derived by feeding a portion of the output signal back to the amplifier input. GAIN potentiometer A1R1 sets the gain of the amplifier by varying the amount of inverse feedback. As the amplitude of feedback increases, amplifier gain decreases.

RESET potentiometer A1R2 sets the stability of the control loop by changing the reset time constant of the feedback signal. The time constant is the product of the value of RESET potentiometer A1R2 and integrating capacitor A1A1C4. As the time constant increases, reset time increases. This increases stability by slowing the response time.

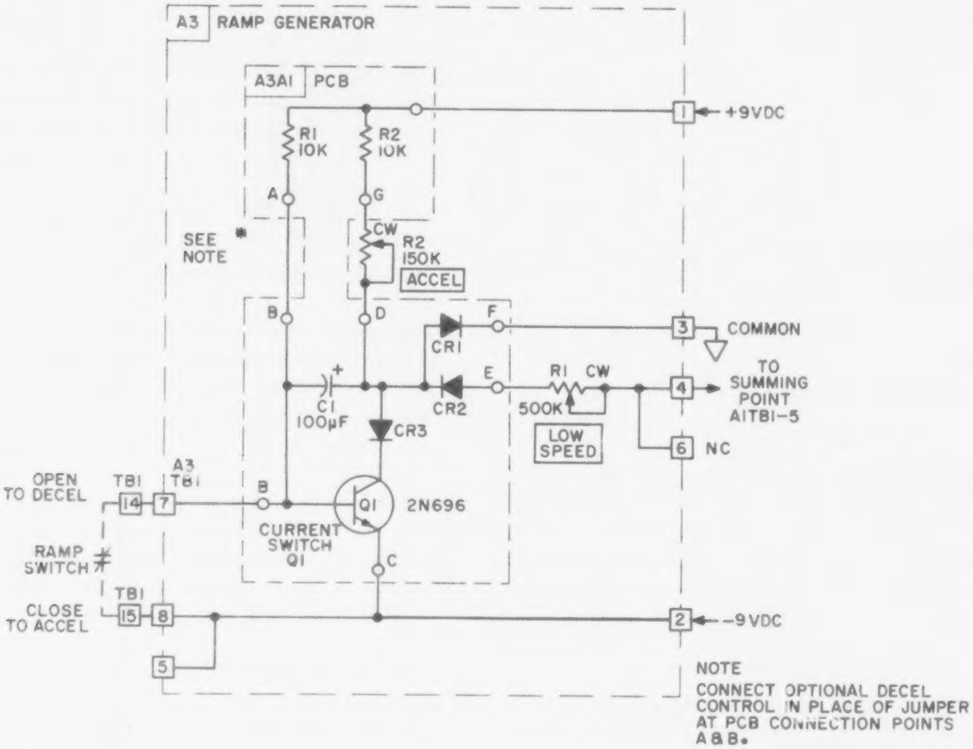
A high-frequency feedback circuit consisting of A1A1R16/C8 and A1A1R19/C9 compensates for any high-frequency interference which might be introduced.

Derivative capacitor A1A1C11 provides derivative control action for the amplifier by effectively acting as a short circuit to common for the feedback signal when there is a step change in the output voltage. This allows the amplifier to reach maximum gain momentarily. Then the effect is dissipated exponentially to zero.

For single actuator operation, A1TB1 terminal 8 is connected to d.c. common terminal 6. For multiple actuator operation, terminal 8 is connected to the +9-volt power supply at terminal 1.

Ramp Generator

Ramp generator (fig. 5-17) A3 biases the speed setting input signal to the amplifier module in either of two modes: a deceleration mode to a low speed or an acceleration mode.


A3 RAMP GENERATOR
A3A1 PCB
R1
10K
R2
10K
A
G
SEE NOTE
*
CW
R2
150K
ACCEL
B
D
F
CR1
+
C1
100µF
E
CR2
R1 CW
500K
LOW SPEED
CR3
+9VDC
1
3
COMMON
4
TO SUMMING POINT A1TB1-5
6
NC
OPEN TO DECEL
TB1
14
7
A3 TB1
B
Q1
2N696
CURRENT SWITCH Q1
C
RAMP SWITCH
TB1
CLOSE TO ACCEL
15
8
2
-9VDC
5

NOTE
CONNECT OPTIONAL DECEL CONTROL IN PLACE OF JUMPER AT PCB CONNECTION POINTS A & B.

111.207X

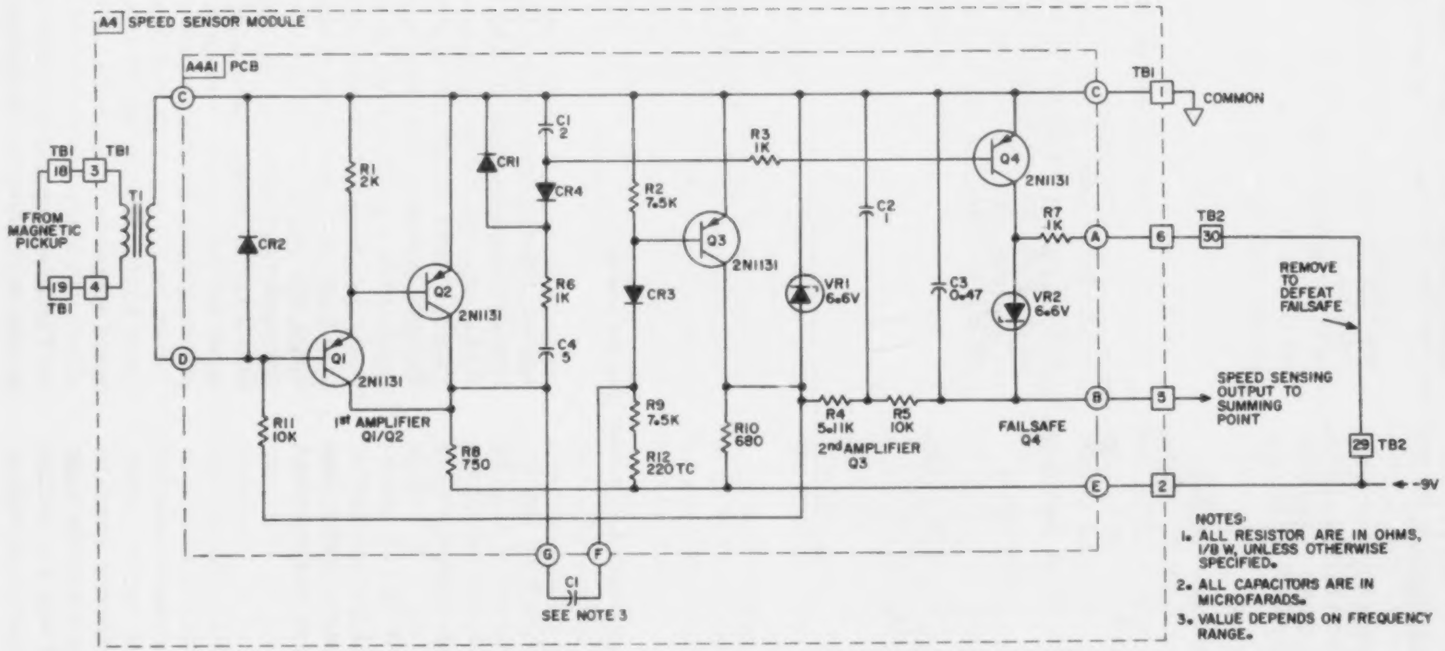
Figure 5-17.—Ramp generator schematic.

DECELERATION MODE.—With the external switch or contacts (connected to TB1 terminals 14 and 15) open, the positive voltage from A3A1R1 forward biases current switch A3A1Q1. With Q1 turned on, −9 volt is connected through Q1 to LOW SPEED potentiometer A3R1. The LOW SPEED potentiometer sets the amount of negative speed setting bias voltage to hold the prime mover at the desired idle speed.

ACCELERATION MODE.—Closing the external ramp switch or contacts connected to TB1 terminals 14 and 15, connects −9 volt d.c. to timing capacitor A1C1 and current switch A3A1Q1. This reverse biases Q1 and stops the current flow through Q1. This allows the right side of C1 to charge from −9 volt d.c. toward +9 volt d.c. This positive ramp voltage is applied through gate diode A3A1CR2 to the amplifier summing point. ACCEL potentiometer A3R2 sets the charge time constant of the circuit, thereby setting the acceleration rate of the ramp generator. The ramping output voltage continues in a positive direction until it reaches 0 volt d.c. As the ramp becomes more positive than 0 volt d.c., gate diode A3A1CR1 forward biases and begins to conduct. This clamps the ramp generator output to +0.6 volt d.c. At this time the prime mover should be at or near rated speed and the reference voltage at the summing point will be 0 volt d.c.

Speed Sensor

The speed input signal from the magnetic pickup is applied to interstage transformer


A4 SPEED SENSOR MODULE
A4A1 PCB
TB1
18
3
19
4
FROM MAGNETIC PICKUP
T1
C
D
CR2
R1 2K
R11 10K
Q1
2N1131
Q2
2N1131
1st AMPLIFIER Q1/Q2
R8 750
CR1
C1 2
CR4
R6 1K
C4 5
R2 7.5K
CR3
R9 7.5K
R12 220 TC
Q3
2N1131
R10 680
R3 1K
VR1 6.6V
R4 5.11K
R5 10K
2nd AMPLIFIER Q3
C2 1
C3 0.47
Q4
2N1131
R7 1K
VR2 6.6V
FAILSAFE Q4
G
F
C1
SEE NOTE 3
A
B
E
1
6
5
2
COMMON
TB2
30
29
REMOVE TO DEFEAT FAILSAFE
SPEED SENSING OUTPUT TO SUMMING POINT
-9V

NOTES:
1. ALL RESISTOR ARE IN OHMS, 1/8 W, UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS.
3. VALUE DEPENDS ON FREQUENCY RANGE.

111.208X

Figure 5-18.—Speed sensor schematic.

A4T1 (see fig. 5-18). Transformer T1 provides a 1 to 3 step-up ratio of the speed input signal. The alternating input signal from T1 alternately drives first amplifier A4A1Q1/Q2 into saturation and cutoff. This clipped sine wave output signal is applied to the selectable time constant differentiator network.

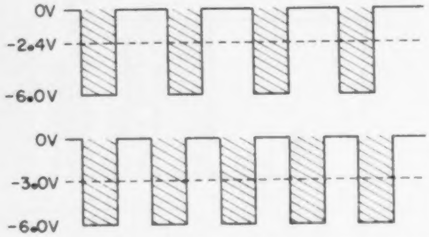
Differentiator networks A4C1/A4A1R9 and R12 convert the clipped sine wave from the first amplifier to corresponding positive and negative-going spikes. Capacitor A4C1 is selectable to set the proper time constant for the particular engine speed for which the 2301 electric control is used. The value of capacitance selected determines the decay time of the positive and negative spikes.

The positive- and negative-going spikes are applied to gate diode A4A1CR3. The gate diode passes only the negative-going spikes and rejects the positive spikes. These negative spikes trigger the second amplifier A4A1Q3.

Biasing for the second amplifier is such that it operates as a saturation switch. The negative trigger spikes saturate Q3 and holds Q3 saturated until the spike decays sufficiently below the threshold voltage to turn Q3 off. This produces a pulsed output with the frequency determined by the engine speed and the pulse width determined by the selected time constant. Zener diode A4A1VR1 clamps the maximum pulse excursion to 6.6 volt.

As the engine rpm increases, so does the frequency of the speed input signal (see fig. 5-19). The value of capacitance selected sets the speed range of the speed sensor to match the requirements of the engine. Higher rpm engines require a faster differentiator network time constant. This maintains the proper ratio between the pulse width and the pulse period (time between pulses).

The output from second amplifier Q3 is filtered by a two stage RC filter consisting of R4/C2 and R5/C3. For all practical purposes, the filtered output voltage is proportional to the engine speed (see fig. 5-19). If the engine speed decreases, the frequency of the differentiated spikes decreases. This increases the time between pulses. Since the pulse width is determined by the differentiator time constant, the pulse width remains the same. This decreases the average d.c. voltage level from the filter circuit.



NOTE: BASIC ENVELOPE DEVELOPED ACROSS A4A1VR1. DASHED LINE INDICATES AVERAGE FILTERED DC VOLTAGE OUTPUT. SHADED AREA EMPHASIZES EQUAL AREA PULSES.

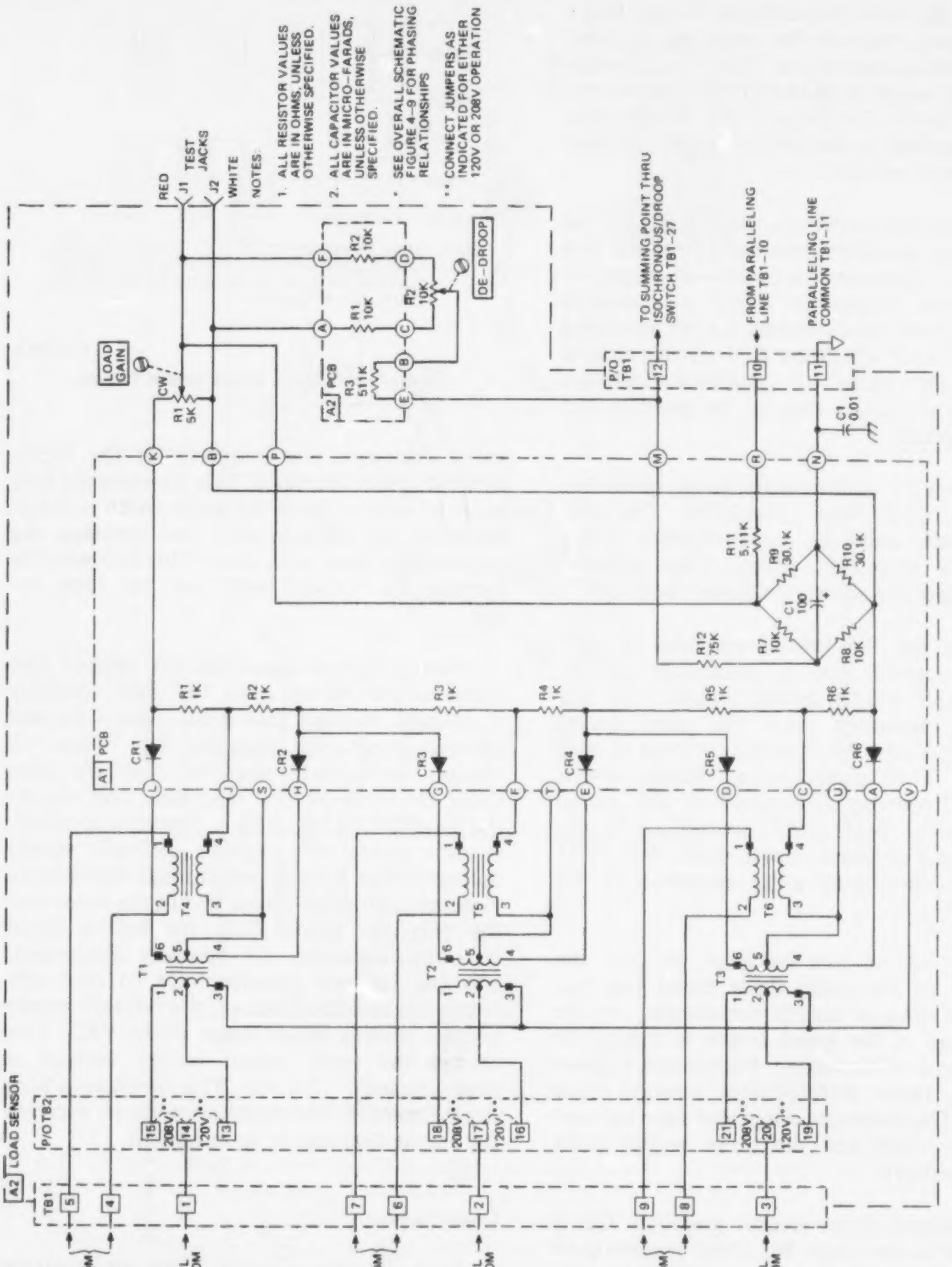
111.209X

Figure 5-19.—Speed sensor output voltage.

During normal operation the clipped sine wave output signal from the first amplifier is coupled through gate diode A4A1CR4 and charges integrating capacitor C1. When C1 charges sufficiently negative, fail-safe transistor Q4 turns on and saturates. This clamps the anode of VR2 at the d.c. common potential. In this mode the negative fail-safe supply voltage (which is connected through the fail-safe jumper) is dropped across R7. In the event that the magnetic pickup fails (or before initial start-up), capacitor C1 becomes discharged, allowing fail-safe transistor Q4 to turn off. When this condition occurs, the fail-safe supply voltage reverse biases zener diode VR2. This clamps the speed sensor output voltage at approximately -2.4 volt. This simulates a high engine speed to the summing point to decrease the engine fuel supply to minimum.

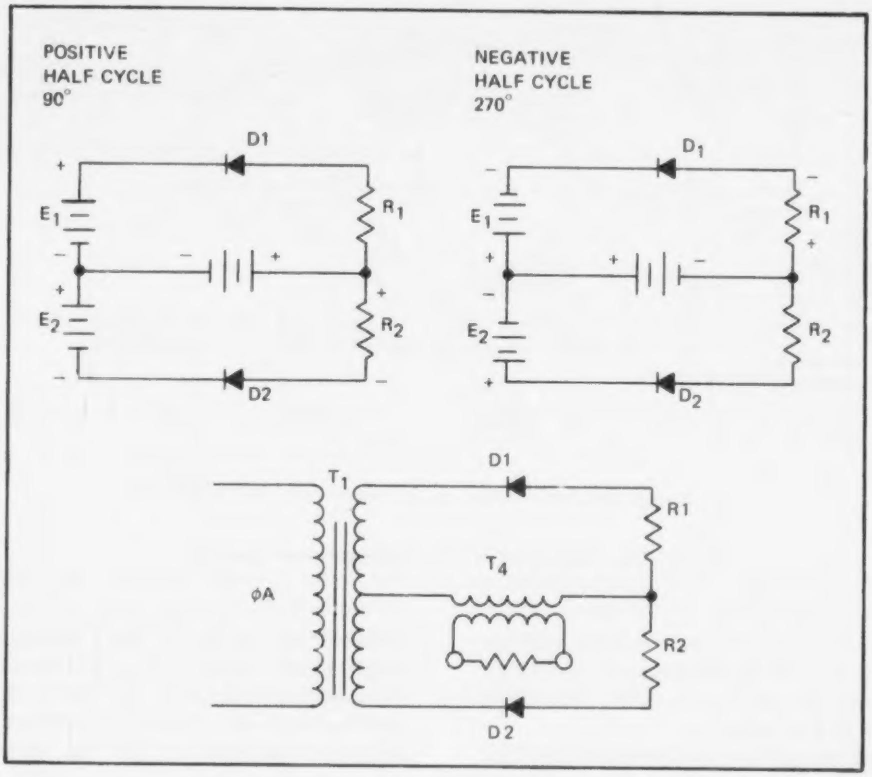
Load Sensor

In the load sensor (fig. 5-20) A2 monitors the voltage levels from the external potential and current transformers. From these input signals,


A2 LOAD SENSOR
TB1
P/OTB2
PHASE A CURRENT INPUT FROM BURDEN RESISTOR R3*
PHASE A POTENTIAL INPUT FROM TB1-1
PHASE B CURRENT INPUT FROM BURDEN RESISTOR R2*
PHASE B POTENTIAL INPUT FROM TB1-2
PHASE C CURRENT INPUT FROM BURDEN RESISTOR R1*
PHASE C POTENTIAL INPUT FROM TB1-3
208V
120V
T1
T2
T3
T4
T5
T6
A1 PCB
CR1
CR2
CR3
CR4
CR5
CR6
R1 1K
R2 1K
R3 1K
R4 1K
R5 1K
R6 1K
R1 5K
CW
LOAD GAIN
RED
J1
TEST JACKS
J2
WHITE
A2 PCB
R3 511K
R1 10K
R2 10K
R2 10K
DE-DROOP
R12 75K
R7 10K
C1 100
R8 10K
R9 30.1K
R10 30.1K
R11 5.11K
C1 0.01
P/O TB1
TO SUMMING POINT THRU ISOCHRONOUS/DROOP SWITCH TB1-27
FROM PARALLELING LINE TB1-10
PARALLELING LINE COMMON TB1-11
NOTES:
1. ALL RESISTOR VALUES ARE IN OHMS, UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE IN MICRO-FARADS, UNLESS OTHERWISE SPECIFIED.
* SEE OVERALL SCHEMATIC FIGURE 4-9 FOR PHASING RELATIONSHIPS
** CONNECT JUMPERS AS INDICATED FOR EITHER 120V OR 208V OPERATION

111.210X

Figure 5-20.—Load sensor schematic.



111.211X

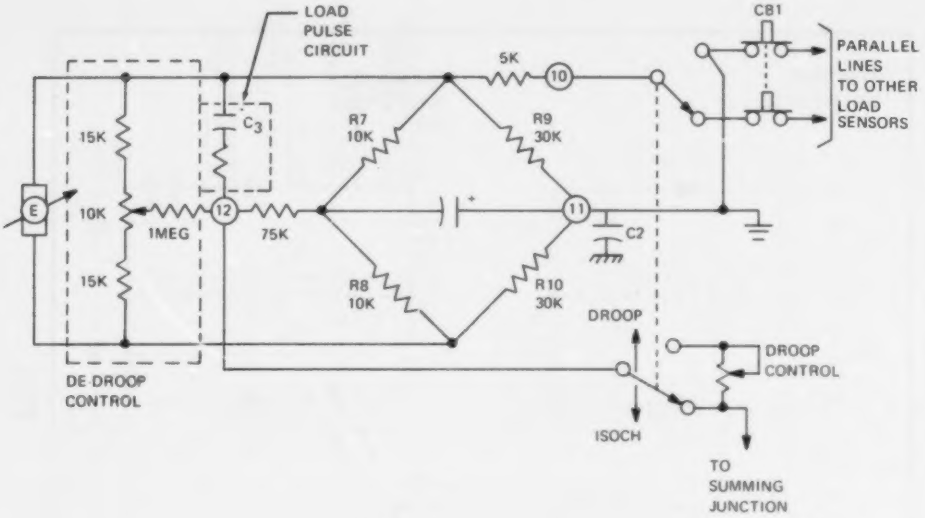
Figure 5-21.—Equivalent single-phase circuit.

the load sensor computes the total kW load on the generator and produces a d.c. voltage proportionate to the load.

Figure 5-21 shows one phase of the load sensor and the equivalent voltage circuits for 90° and 270° transition through the sine wave. As shown, current input transformer T4 can be represented by battery E3, the value and polarity of which is dependent on load and sine wave transition. During the positive half cycle, the E1 and E2 voltages are maximum at 90°. During this half cycle diode CR1 reverse biases and CR2 forward biases and conducts. At this time the polarity of E3 adds to E2 with the total voltage developed across R2. During the negative half cycle, the E1 and E2 voltages are again maximum, only in the opposite polarity. This forward biases CR1 and reverse biases CR2. E3 also changes polarity during the negative half cycle. Since E3 and E1 are opposite in polarity, the voltage developed across R1 is E1 minus E3. During periods of no load, the voltage at E3 is 0 V and the voltage developed across R1 and R2 is equal to the voltage at E1 and E2.

During no load there is no current signal and consequently no voltage is developed across the current transformer. This results in a 0 volt load signal since the three phases cancel each other out.

LOAD GAIN control A2R1 (fig. 5-20) is connected in parallel with the voltage adder circuit. The output of the variable LOAD



111.212X

Figure 5-22.—Basic load sensor, single unit configuration.

GAIN control (represented as variable voltage source E in fig. 5-22) is applied across the bridge circuit. This then is the load control signal for this particular prime mover.

A de-droop circuit is connected across the output of the LOAD GAIN potentiometer and applies a portion of this load voltage as bias to the output of the load sensor. This counteracts any inherent droop in the overall system.

An optional load pulse circuit (fig. 5-22) differentiates any sudden load voltage output from the LOAD GAIN control caused by a sudden load change. The load pulse provides a lead signal to the amplifier summing point and minimizes the off speed and recovery time associated with large and sudden load changes.

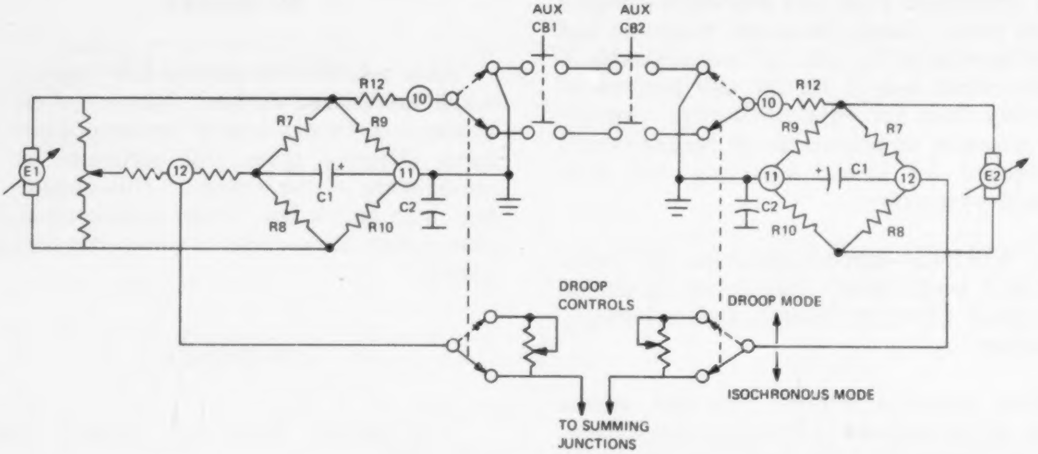
SINGLE UNIT ISOCHRONOUS.—During single unit isochronous operation, the bridge circuit is balanced; thus the load sensor output is 0 volt. Under this condition the speed sensor maintains engine speed.

SINGLE UNIT DROOP.—Setting the external mode switch to DROOP, connects A1R11 to d.c. common. This unbalances the bridge network, producing a difference in voltage between terminals 11 and 12. As the load on the generator increases, the load voltage from the bridge circuit (terminal 12) increases negatively. This negative voltage is applied to the DROOP potentiometer which sets the amount of series resistance. In this mode the negative load voltage biases the speed setting signal downward as the load increases.

PARALLEL UNIT ISOCHRONOUS.—The load sensor provides proportional load sharing when two or more generating units are parallel in the isochronous mode. In this mode each load sensor compares the load of its generating unit with the load of other units producing power and either increases or decreases fuel to the engine to maintain its proportional share of the load.

When the mode switches are set for isochronous operation for a parallel engine combination, their load sensor bridge circuits are connected together through the paralleling lines (see fig. 5-23). In this mode of operation, the bridge circuits are balanced with terminal 11 as a common reference point.

When paralleling two or more units, each engine takes on its proportional share of the load by equalizing the load voltages across the bridge network.



111.213X

Figure 5-23.—Basic load sensor, parallel unit configuration.

As an example, assume that 2 units are paralleled. The first unit has a 100-kW capacity and the second has 50 kW. Unit 1 is operating at 75-percent capacity and unit 2 is at rated speed with no load. The load sensor for both units is calibrated for 9 volts at full load. However, E1 for unit 1 is 6.75 volts (9 volts × 0.75) and E2 for unit 2 is 0 volt (9 volts × 0.00) caused by the different load conditions. This condition exists at the moment of paralleling, causing an electrical imbalance between the two load sensor bridge networks. The imbalance causes a circulating current between the two bridge networks and produces a positive output voltage to the summing point of unit 2 and a negative output voltage to the summing point of unit 1. This causes unit 2 to take on load and unit 1 to shed load. As unit 2 takes on load, E2 increases from 0 volts. As unit 1 sheds load, E1 decreases from 6.75 volts. The circulating current then decreases. This continues until E1 equals E2 (4.5 volts) and both generators share the load proportionally. Unit 1 is producing 50 kW, and unit 2 is producing 25 kW for a total power of 75 kW.

The load sensors are only active during unequal load changes when a circulating current develops between the bridge networks. During an unequal change, the bridge networks are electrically unbalanced, and the action is always toward proportional load sharing.

MAINTENANCE

Maintenance for the 2301 electric governor should be conducted on a regular basis. The first step in the procedure is to look for any obvious physical defects. Missing, loose, or damaged electrical or mechanical connections often result in more serious maintenance problems if not corrected. Other maintenance suggestions are listed below.

- TRANSFORMERS—Inspect all transformers for loose or broken terminals. Check all mounting hardware.

- CONTROLS—Inspect all controls for loose mounting, damaged wipers, or contacts and smoothness of operation. Do not disturb the setting of a screwdriver-adjusted control unless it is suspected of being faulty.

- TERMINAL BLOCKS—Inspect all terminal blocks for cracks, chips, or loose mounting hardware. Check all wiring terminals for loose wires or lugs.

- PRINTED CIRCUIT BOARDS—Inspect printed circuit boards for secure mounting and proper location in the unit. It is not advisable to remove circuit boards for the sole purpose of inspecting them for physical damage. Components mounted on printed circuit boards should be checked for secure mounting and poor electrical connections.

- WIRING—Inspect all wiring for frayed or burned leads. Insure that insulating sleeves are in place. Check for loose or broken lacing in hardnesses.

When power is secured, dust and foreign matter can be removed by brushing with a clean, dry brush. Large surfaces should be wiped with a clean, dry, lint-free cloth. Compressed air at low pressure may be used to blow dust from hard to reach areas. When using compressed air for cleaning, always direct the first blast at the deck. This will blow any accumulation of moisture from the air line.

Use a nonlubricating electrical contact cleaner when potentiometers have erratic control.

SUMMARY

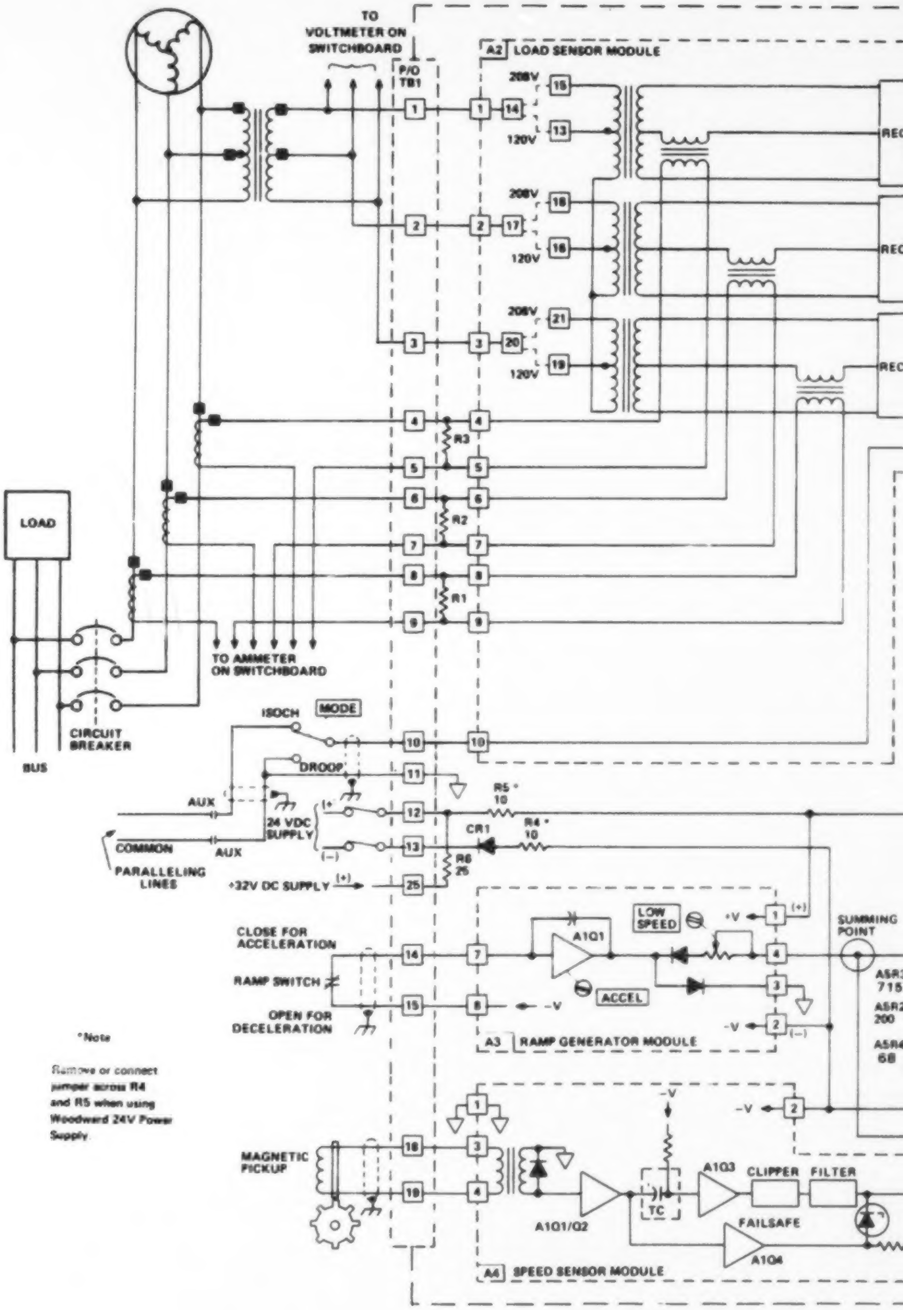
After you have completed this chapter, you should understand the basic function of electrohydraulic governor control systems. There are many different types and variations in the components of the systems. This chapter has dealt with only a few. When making repairs on your system, always refer to the correct technical manual.

REFERENCES

Electricians' Mate C7 School Course A-652-0063

Woodward Governor Bulletins:

1. Hydraulic Amplifier 89005
2. EG-3C and EG-R Actuators 37710G
3. EGB-2P Governor/Actuator 82570G
4. 2301 Load- and Speed-Sensing Control 82517E


TO VOLTMETER ON SWITCHBOARD
P/O TB1
A2 LOAD SENSOR MODULE
208V
120V
REC
R3
R2
R1
LOAD
TO AMMETER ON SWITCHBOARD
CIRCUIT BREAKER
BUS
ISOCH
MODE
DROOP
AUX
24 VDC SUPPLY
COMMON
AUX
PARALLELING LINES
+32V DC SUPPLY
R5 * 10
CR1
R4 * 10
R6 25
CLOSE FOR ACCELERATION
RAMP SWITCH
OPEN FOR DECELERATION
A1Q1
LOW SPEED
ACCEL
+V
-V
SUMMING POINT
A3 RAMP GENERATOR MODULE
MAGNETIC PICKUP
A1Q1/Q2
TC
A1Q3
CLIPPER
FILTER
FAILSAFE
A1Q4
A4 SPEED SENSOR MODULE

*Note

Remove or connect jumper across R4 and R5 when using Woodward 24V Power Supply.

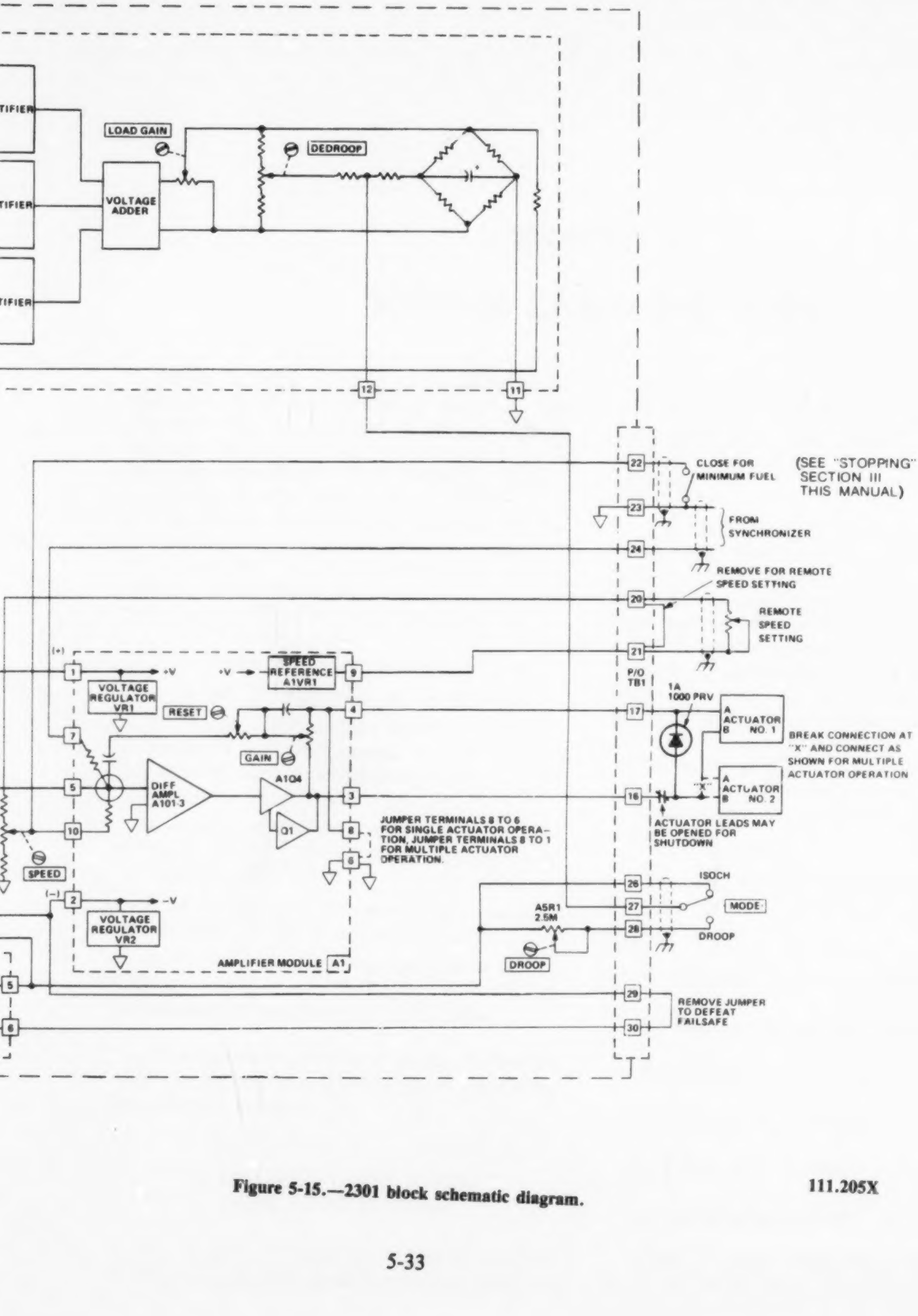

TIFIER
TIFIER
TIFIER
LOAD GAIN
DEDROOP
VOLTAGE ADDER
12
11
22
CLOSE FOR MINIMUM FUEL
(SEE "STOPPING" SECTION III THIS MANUAL)
23
FROM SYNCHRONIZER
24
REMOVE FOR REMOTE SPEED SETTING
20
REMOTE SPEED SETTING
21
(+)
1
+V
VOLTAGE REGULATOR VR1
+V
SPEED REFERENCE A1VR1
9
P/O TB1
RESET
4
17
1A 1000 PRV
A ACTUATOR B NO. 1
7
GAIN
BREAK CONNECTION AT "X" AND CONNECT AS SHOWN FOR MULTIPLE ACTUATOR OPERATION
A1Q4
5
DIFF AMPL A101-3
3
16
"X"
A ACTUATOR B NO. 2
10
Q1
8
JUMPER TERMINALS 8 TO 6 FOR SINGLE ACTUATOR OPERATION, JUMPER TERMINALS 8 TO 1 FOR MULTIPLE ACTUATOR OPERATION.
ACTUATOR LEADS MAY BE OPENED FOR SHUTDOWN
6
SPEED
ISOCH
26
(−)
2
−V
27
MODE
A5R1 2.5M
28
VOLTAGE REGULATOR VR2
DROOP
DROOP
AMPLIFIER MODULE A1
5
29
REMOVE JUMPER TO DEFEAT FAILSAFE
6
30

Figure 5-15.—2301 block schematic diagram.

111.205X

CHAPTER 6

VISUAL LANDING AIDS

Visual Landing Aids (VLA), consisting of helicopter deck area marking, lighting, and approach aids, are required on all Air Capable Ships (ACS) to provide an environment for safe helicopter operations. Deck markings identify the limits of the helicopter operating area, provide line-up information, and identify the safe landing zone. Because of increasing demands for all-weather and night operations, special lighting systems have been designed to provide the helicopter pilot with the following:

1. An initial visual contact with the ship
2. A safe glide path to the landing area
3. Precise information (visual cues) relative to the ship's deck position and any obstructions that may be present during launch and recovery operations
4. Visual indications for helicopter in-flight refueling (HIFR) and vertical replenishment operations (VERTREP)
5. A lighting system to signify any unacceptable landing condition aboard the ship
6. Various other lighting systems to aid the pilot in operating under the more demanding environmental conditions on ACS ships.

All components of the VLA (fig. 6-1) assist both the helicopter and the ship in completing the assigned mission.

STABILIZED GLIDE SLOPE INDICATOR SYSTEM

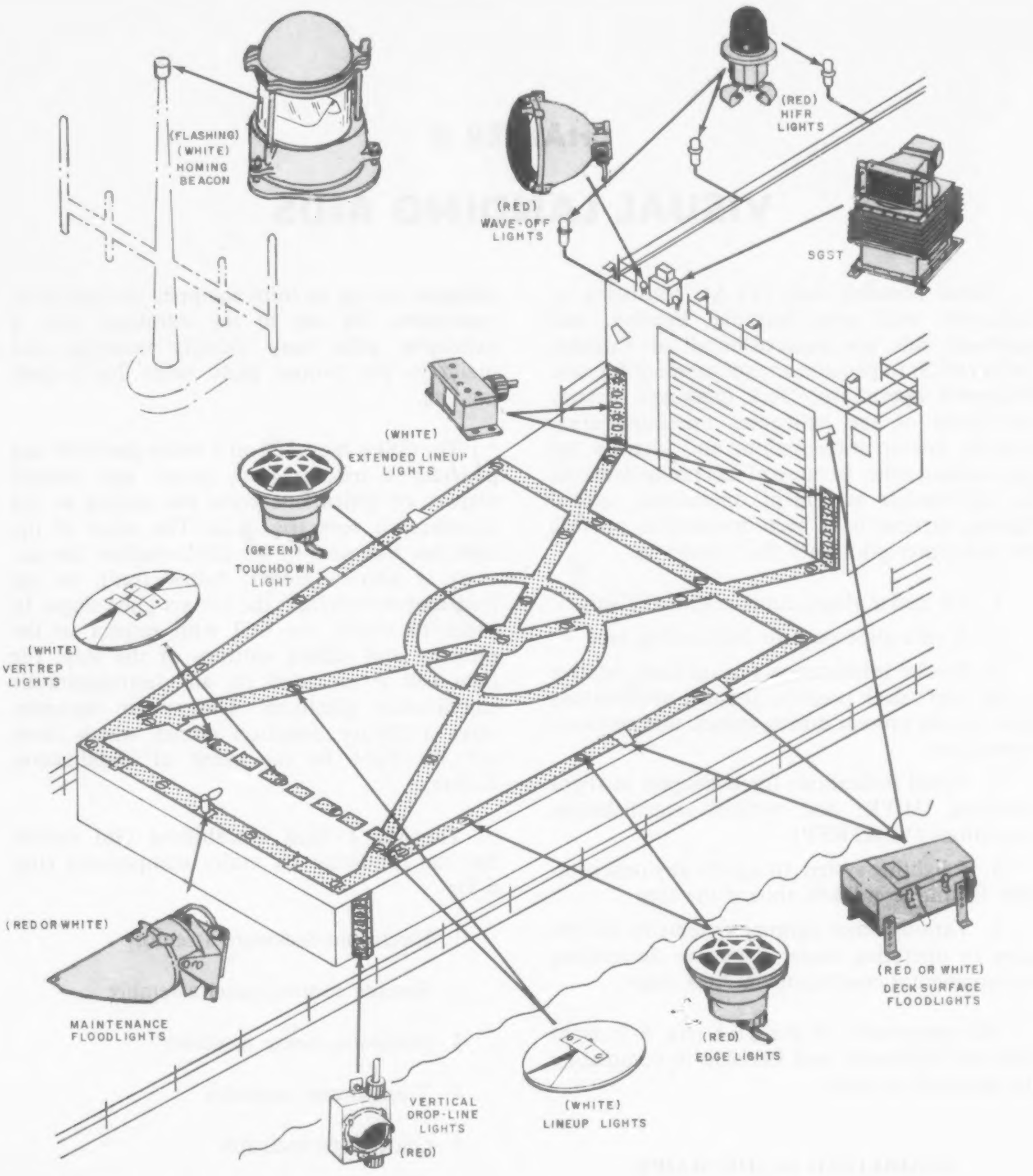
The stabilized Glide Slope Indicator (GSI) System is an electrohydraulic optical landing aid designed for use on ships equipped for helicopter operations. By use of the stabilized GSI, a helicopter pilot may visually establish and maintain the proper glide slope for a safe landing.

The GSI is mounted on a stable platform and provides a tricolor (red, green, and amber) display of which one color (or mixing at the interface) is seen (fig. 6-2). The color of the light bar indicates to the pilot whether the aircraft is above (green), below (red), or on (red/amber interface) the correct glide slope. In order to steady the GSI with respect to the pitching and rolling motions of the ship, the light cell is mounted on an electrohydraulic stabilization platform. The system incorporates a failure detection circuit which turns off the light in the event of stabilization failure.

The Mk 1 Mod 0 stabilized GSI system has the following six major components (fig. 6-3):

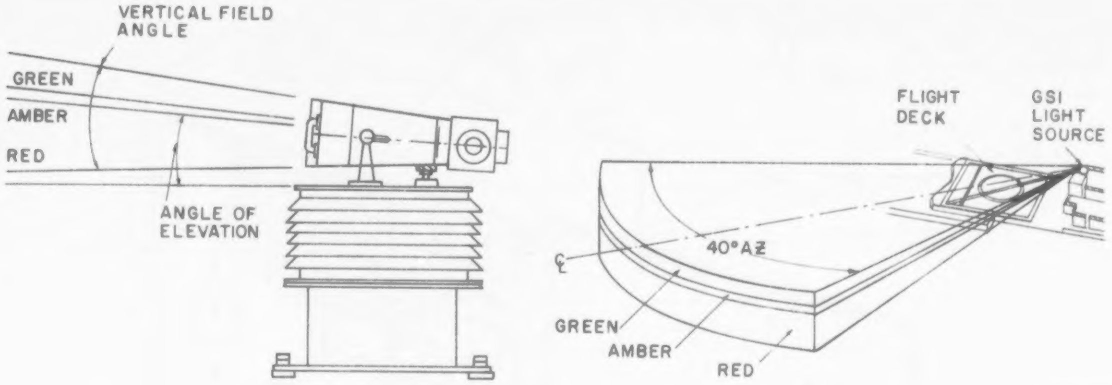
1. Electronic enclosure assembly
2. Remote control panel assembly
3. Hydraulic pump assembly
4. Transformer assembly
5. Glide slope indicator
6. Stabilized platform

Each of these components is discussed in detail in the following paragraphs.


(FLASHING)
(WHITE)
HOMING
BEACON
(RED)
HIFR
LIGHTS
(RED)
WAVE-OFF
LIGHTS
SGST
(WHITE)
EXTENDED LINEUP
LIGHTS
(GREEN)
TOUCHDOWN
LIGHT
(WHITE)
VERTREP
LIGHTS
(RED OR WHITE)
MAINTENANCE
FLOODLIGHTS
(RED OR WHITE)
DECK SURFACE
FLOODLIGHTS
(RED)
EDGE LIGHTS
(WHITE)
LINEUP LIGHTS
VERTICAL
DROP-LINE
LIGHTS
(RED)

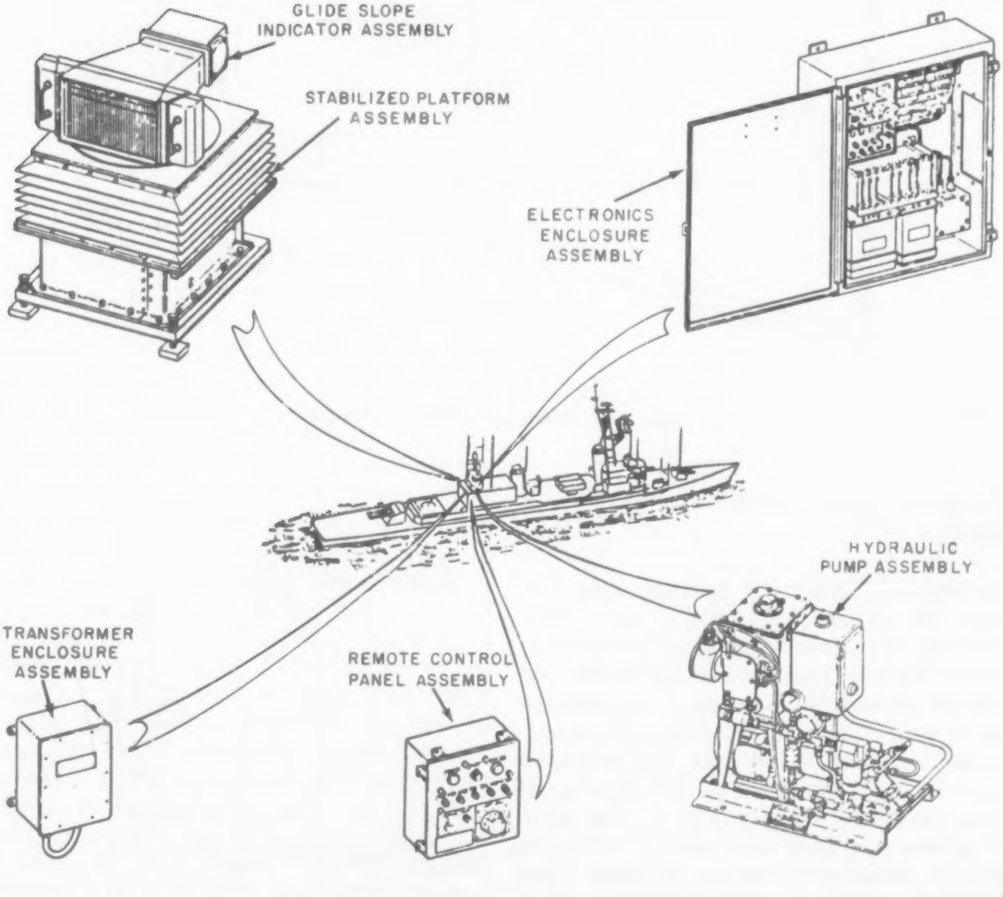
111.171

Figure 6-1.—Typical VLA installations with flight deck and hangar on 0-1 level, dual landing approach.


VERTICAL FIELD ANGLE
GREEN
AMBER
RED
ANGLE OF ELEVATION
FLIGHT DECK
GSI LIGHT SOURCE
℄
40° AZ
GREEN
AMBER
RED

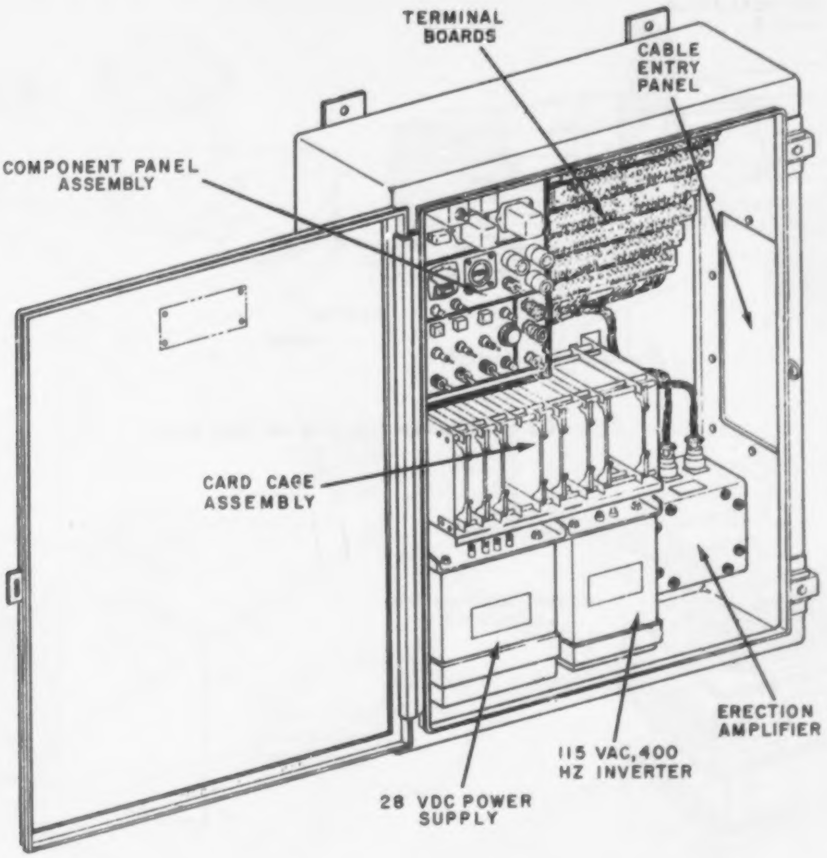
111.172

Figure 6-2.—Glide slope indicator and light beam.


GLIDE SLOPE INDICATOR ASSEMBLY
STABILIZED PLATFORM ASSEMBLY
ELECTRONICS ENCLOSURE ASSEMBLY
HYDRAULIC PUMP ASSEMBLY
TRANSFORMER ENCLOSURE ASSEMBLY
REMOTE CONTROL PANEL ASSEMBLY

111.173

Figure 6-3.—Stabilized glide slope indicator system.

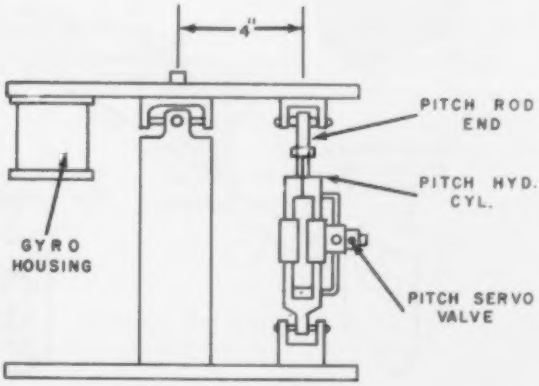

TERMINAL BOARDS
CABLE ENTRY PANEL
COMPONENT PANEL ASSEMBLY
CARD CAGE ASSEMBLY
ERECTION AMPLIFIER
115 VAC, 400 HZ INVERTER
28 VDC POWER SUPPLY

111.174

Figure 6-4.—Electronic enclosure assembly.

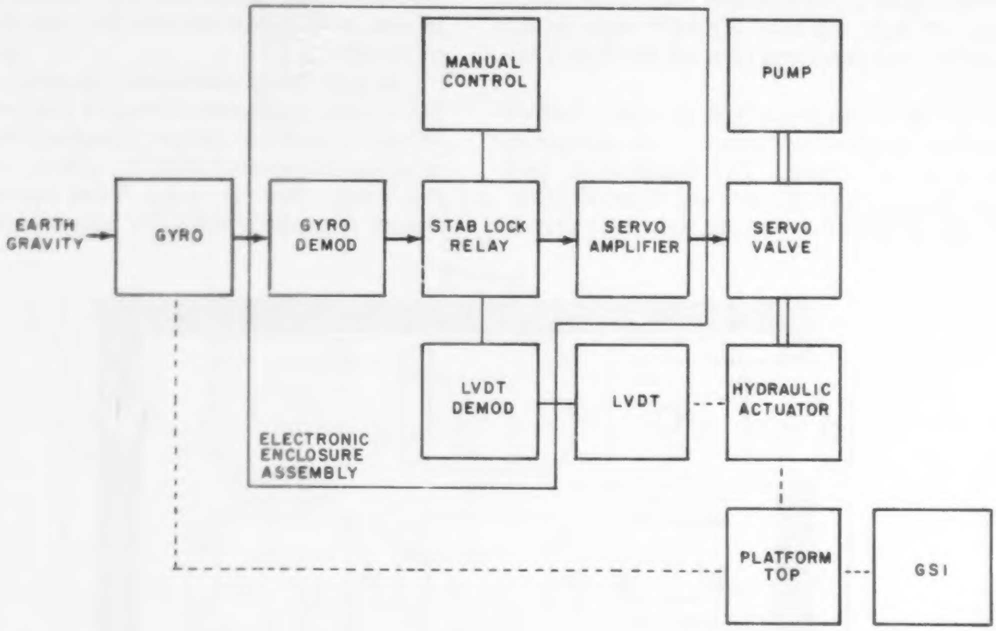
ELECTRONIC ENCLOSURE ASSEMBLY

The electronic enclosure assembly (fig. 6-4) contains the circuits, amplifiers, and other electrical and electronic components required to control the major components of the system. To understand the system operation, it is necessary for you to understand the operation of the feedback control systems. A feedback control system compares an input signal with a reference signal and then generates an error signal. This error signal is then amplified and used to drive the output in a direction to reduce the error. This type feedback system is often referred to as a servo loop. A gyro (fig. 6-5), mounted on the


4"
PITCH ROD END
PITCH HYD. CYL.
GYRO HOUSING
PITCH SERVO VALVE

111.175

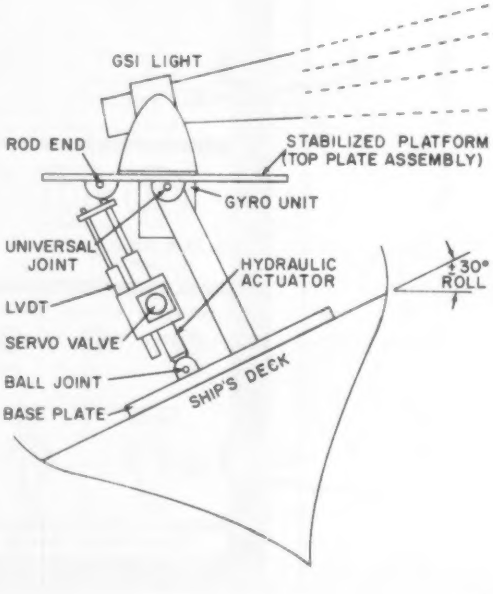
Figure 6-5.—Platform pitch drive.


MANUAL CONTROL
PUMP
EARTH GRAVITY
GYRO
GYRO DEMOD
STAB LOCK RELAY
SERVO AMPLIFIER
SERVO VALVE
LVDT DEMOD
LVDT
HYDRAULIC ACTUATOR
ELECTRONIC ENCLOSURE ASSEMBLY
PLATFORM TOP
GSI

111.176

Figure 6-6.—Block diagram—stabilization circuits.

stabilized platform, acts as the reference of the system. Since the gyro is stable, synchro transmitters located on the gimbals in the gyro will sense any motion of pitch or roll. As the ship begins to pitch or roll, an error signal is developed by the synchro transmitter stators in the gyro. Refer to the block diagram in figure 6-6, and you can follow the path of the error signal through the electronic enclosure assembly. (The block diagram represents either the pitch or the roll control loops since they are identical electrically.) From the transmitter stators of the gyro, the error signal is sent to the gyro demodulator where the signal is changed from a.c. to d.c. The signal then goes through a stabilization lock (stab lock) relay (described later) and is amplified as it moves through the servo amplifier which in turn operates the servo valve. The servo valve opens and allows hydraulic fluid to enter the hydraulic actuator (fig. 6-7). This levels the platform and thus cancels the error signal. When this occurs, a READY light is actuated on the remote control panel. If the system develops a malfunction and


GSI LIGHT
ROD END
STABILIZED PLATFORM (TOP PLATE ASSEMBLY)
GYRO UNIT
UNIVERSAL JOINT
HYDRAULIC ACTUATOR
30° ROLL
LVDT
SERVO VALVE
BALL JOINT
BASE PLATE
SHIP'S DECK

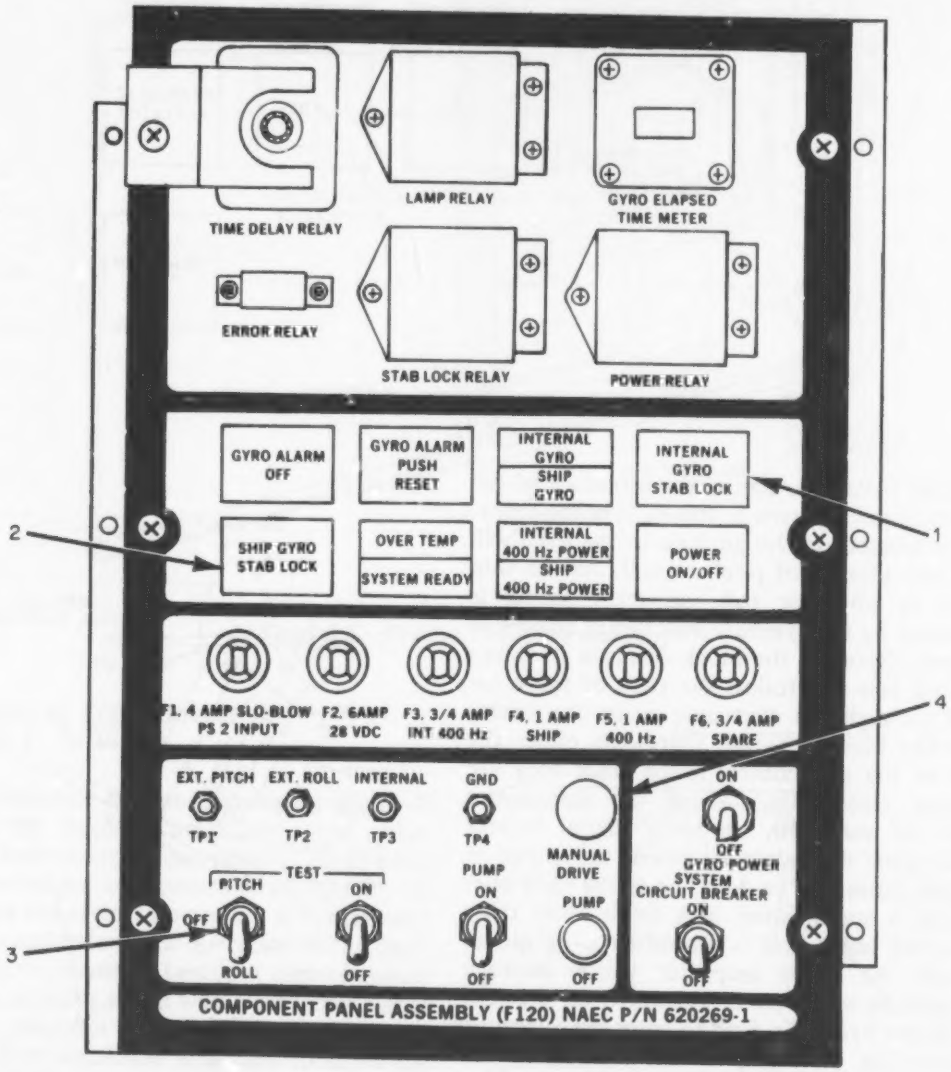
111.177

Figure 6-7.—Stabilized platform assembly—functional diagram.

the error signal is not cancelled, an error-sensing circuit will light the NOT READY light on the remote control panel and turn off the glide slope indicator.

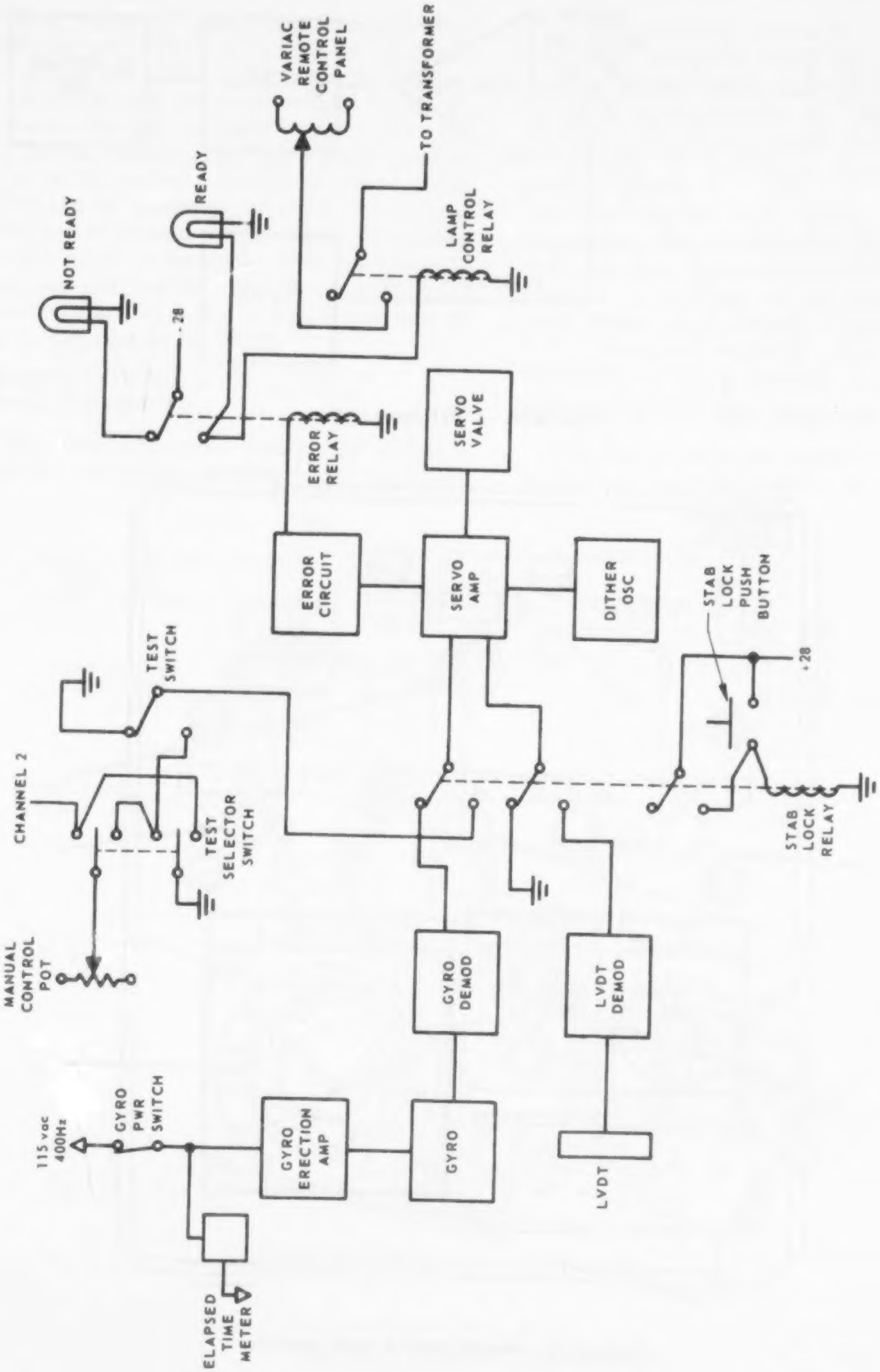
In the previous paragraph you have learned the normal mode of operation in the electronics portion of the system. The stabilization lock feature (stab lock relay) tests and aligns the GSI. Referring to figure 6-8, you will see the (1) internal gyro stab lock, (2) the ship's gyro stab lock push button, and (3) two test switches, one of which is pitch-off-roll.

As previously mentioned, the error signal in the normal mode goes through a stab lock relay. When the stab lock button is pushed, the normal error signal supplied from the gyro is stopped at this point. (See fig. 6-9.) When the stab lock button is pushed, the error signal comes from


TIME DELAY RELAY
LAMP RELAY
GYRO ELAPSED TIME METER
ERROR RELAY
STAB LOCK RELAY
POWER RELAY
GYRO ALARM OFF
GYRO ALARM PUSH RESET
INTERNAL GYRO
SHIP GYRO
INTERNAL GYRO STAB LOCK
1
2
SHIP GYRO STAB LOCK
OVER TEMP
SYSTEM READY
INTERNAL 400 Hz POWER
SHIP 400 Hz POWER
POWER ON/OFF
F1. 4 AMP SLO-BLOW PS 2 INPUT
F2. 6AMP 28 VDC
F3. 3/4 AMP INT 400 Hz
F4. 1 AMP SHIP
F5. 1 AMP 400 Hz
F6. 3/4 AMP SPARE
4
EXT. PITCH
EXT. ROLL
INTERNAL
GND
TP1
TP2
TP3
TP4
MANUAL DRIVE
ON
OFF
GYRO POWER SYSTEM CIRCUIT BREAKER
ON
OFF
TEST
PITCH
OFF
ROLL
3
ON
OFF
PUMP
ON
OFF
PUMP
OFF
COMPONENT PANEL ASSEMBLY (F120) NAEC P/N 620269-1

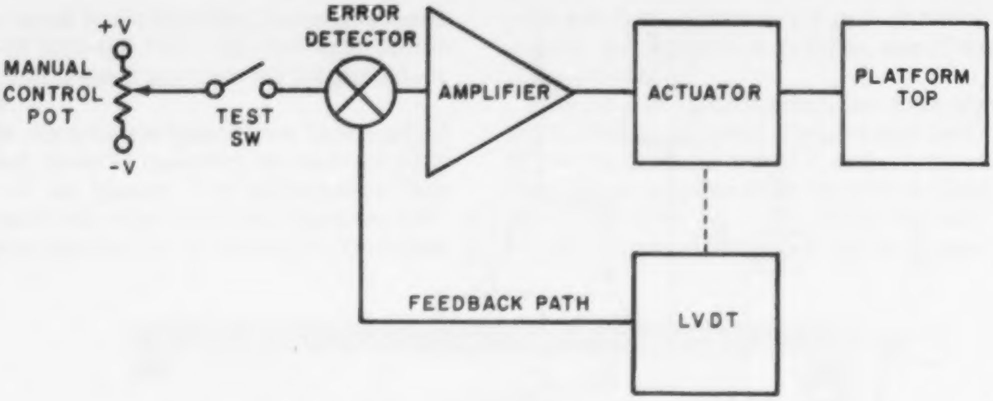
111.214

Figure 6-8.—Component panel assembly.


VARIAC
REMOTE
CONTROL
PANEL
TO TRANSFORMER
NOT READY
READY
+28
LAMP
CONTROL
RELAY
ERROR
RELAY
SERVO
VALVE
ERROR
CIRCUIT
SERVO
AMP
DITHER
OSC
CHANNEL 2
TEST
SWITCH
TEST
SELECTOR
SWITCH
STAB
LOCK
PUSH
BUTTON
+28
STAB
LOCK
RELAY
MANUAL
CONTROL
POT
GYRO
DEMOD
LVDT
DEMOD
115 vac
400Hz
GYRO
PWR
SWITCH
GYRO
ERECTION
AMP
GYRO
LVDT
ELAPSED
TIME
METER

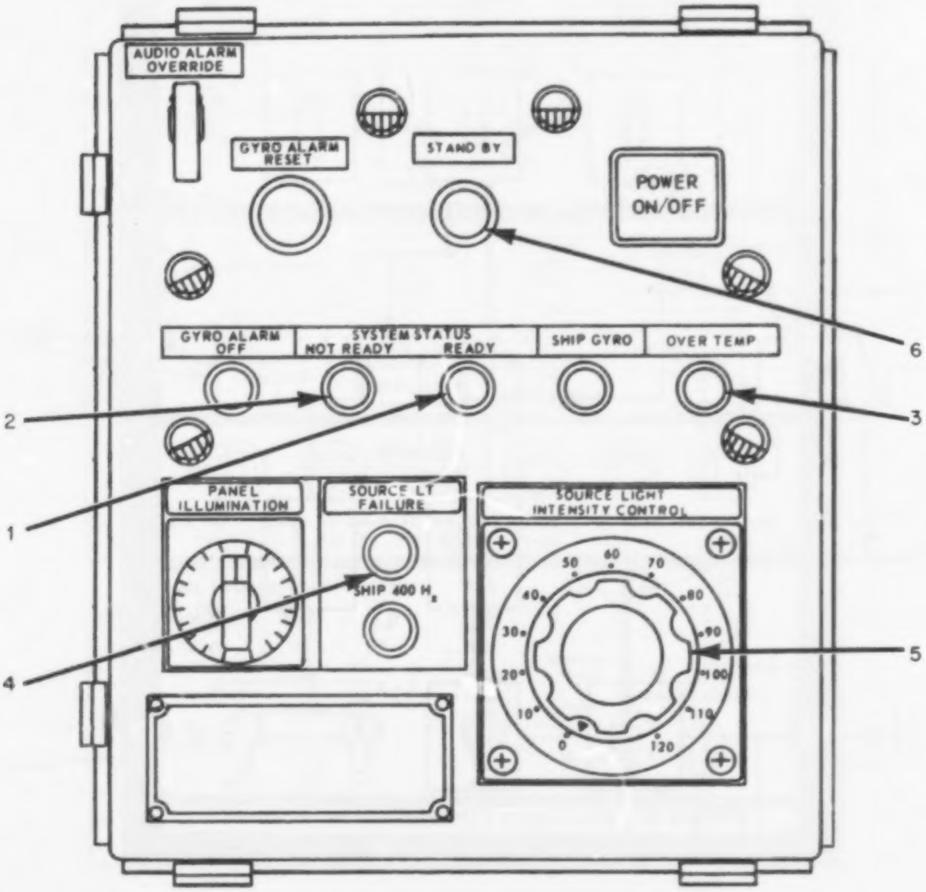
111.215

Figure 6-9.—Stabilization control circuits—signal flow.


+V
MANUAL CONTROL POT
-V
TEST SW
ERROR DETECTOR
AMPLIFIER
ACTUATOR
PLATFORM TOP
FEEDBACK PATH
LVDT

111.180

Figure 6-10.—LVDT servo loop.


AUDIO ALARM OVERRIDE
GYRO ALARM RESET
STAND BY
POWER ON/OFF
GYRO ALARM OFF
SYSTEM STATUS
NOT READY
READY
SHIP GYRO
OVER TEMP
PANEL ILLUMINATION
SOURCE LT FAILURE
SHIP 400 Hz
SOURCE LIGHT INTENSITY CONTROL
0
10
20
30
40
50
60
70
80
90
100
110
120
1
2
3
4
5
6

111.216

Figure 6-11.—Remote control panel assembly.

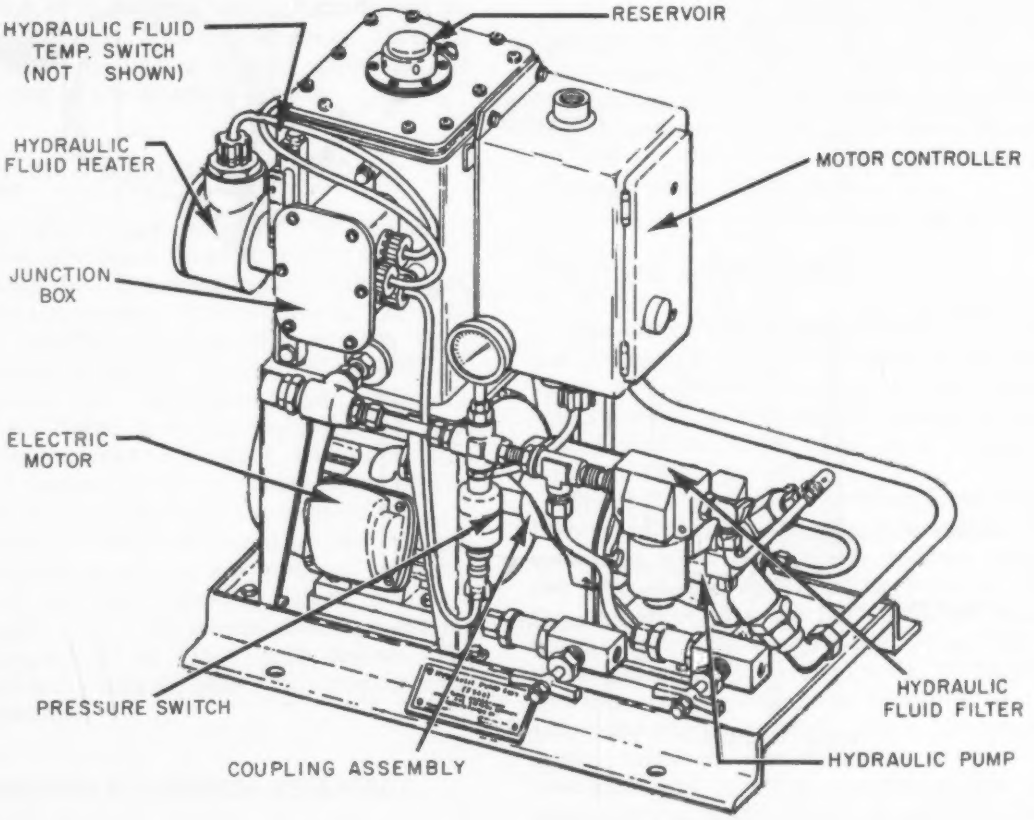
the linear voltage differential transformer (LVDT) when the test switch is in the off position. The core of the LVDT is mechanically attached to the hydraulic actuator which levels the platform. As the actuator moves, the core also moves, thereby supplying a signal proportional to the amount of roll or pitch. These signals can be measured to aid in the maintenance and alignment of the system. Provisions are also made to manually drive the platform using the test switches and the manual drive potentiometer ((4) in fig. 6-8 and may also be seen in diagram of fig. 6-10).

REMOTE CONTROL PANEL ASSEMBLY

The remote control panel (fig. 6-11) is located in the helicopter control station (HCS). This panel provides control and indicators for operating and monitoring the stabilized GSI from a remote location. It contains the READY (1) and NOT READY (2) lights described previously. The panel also contains an OVER TEMP light (3) to indicate when the hydraulic fluid is heated to a temperature higher than 135 °F ± 5 degrees; a source failure light (4) that illuminates when a projection lamp in the GSI indicator fails; the variable transformer (5) that controls the intensity of the GSI light; and a panel illumination control. A standby light (6) will be energized when the main switch on the electronic enclosure assembly is on.

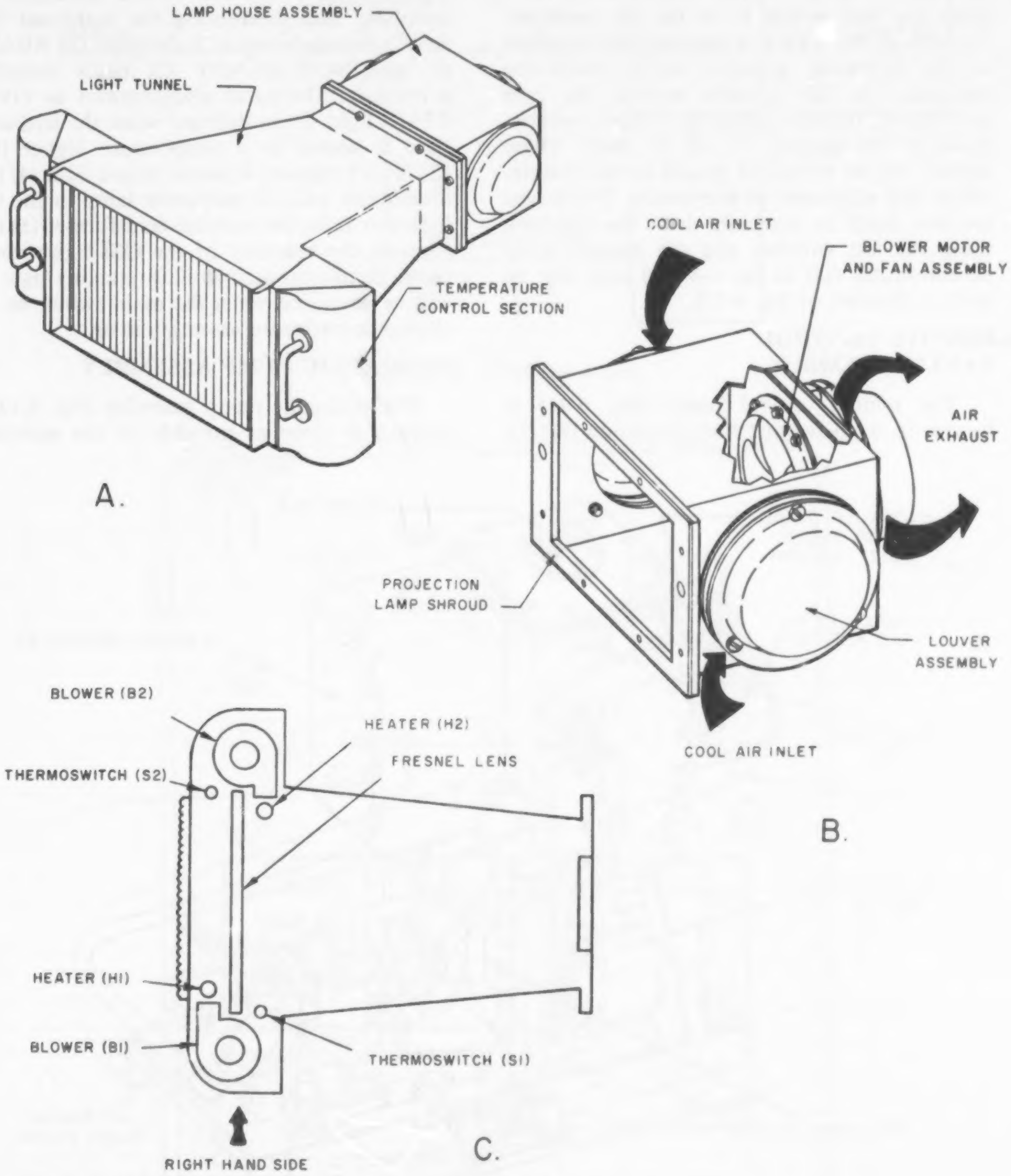
HYDRAULIC PUMP ASSEMBLY

The hydraulic pump assembly (fig. 6-12) is located as close as possible to the stabilized


HYDRAULIC FLUID TEMP. SWITCH (NOT SHOWN)
RESERVOIR
HYDRAULIC FLUID HEATER
MOTOR CONTROLLER
JUNCTION BOX
ELECTRIC MOTOR
PRESSURE SWITCH
COUPLING ASSEMBLY
HYDRAULIC FLUID FILTER
HYDRAULIC PUMP

111.182

Figure 6-12.—Hydraulic pump assembly.


LAMP HOUSE ASSEMBLY
LIGHT TUNNEL
TEMPERATURE CONTROL SECTION
A.
COOL AIR INLET
BLOWER MOTOR AND FAN ASSEMBLY
AIR EXHAUST
PROJECTION LAMP SHROUD
LOUVER ASSEMBLY
COOL AIR INLET
B.
BLOWER (B2)
HEATER (H2)
FRESNEL LENS
THERMOSWITCH (S2)
HEATER (H1)
BLOWER (B1)
THERMOSWITCH (S1)
RIGHT HAND SIDE
C.

111.183

Figure 6-13.—A. Glide slope indicator; B. Lamp house assembly; C. Temperature control section.

platform. It provides hydraulic fluid at 1,400 psi to the hydraulic actuator on the stabilized platform. The motor and controller operate on 440-V three phase received from the ship's normal power supply. The temperature switches (not shown) operate the HIGH TEMP light on the remote control panel. Also, a pressure switch in the hydraulic pump discharge line will close at 1,200 psi. If not closed, the pressure switch will deenergize the electronic panel assembly on low oil pressure. Hydraulic fluid heaters in the oil reservoir will warm the fluid up to 70°F ±5 degrees before use of the GSI system.

TRANSFORMER ASSEMBLY

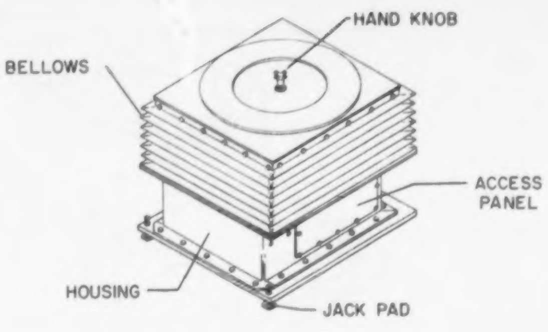
The transformer assembly is located as close as possible to the stabilized platform. Its purpose is to step down the voltage for the source light (GSI) from 0- to 115-volts a.c. to 0- to 18.5-volts a.c. depending on the setting of the intensity control.

GLIDE SLOPE INDICATOR (GSI)

The glide slope indicator (fig. 6-13A) is a cell assembly made up of three main sections—the lamp house assembly, the light tunnel, and the temperature control section. The lamp house assembly (fig. 6-13B) contains three source lights, a vent fan to cool the section, an optical lens (not shown), and reflectors. The light tunnel provides space for the focal length of the lens to be utilized. The temperature control section (fig. 6-13C) contains the Fresnel lens which is sensitive to temperature. To maintain constant temperature, two heaters, each having a blower, are mounted on either side of the cell assembly. Each heater is controlled by a thermostat which maintains the temperature at 115°F ±15 degrees. The blowers recirculate the heated air throughout the cell assembly.

STABILIZED PLATFORM ASSEMBLY

The stabilized platform assembly (fig. 6-14), which will remain level despite the pitch and roll attitude of the ship, provides a mount for the GSI. The assembly, shown in figure 6-15, consists of a stabilized platform attached to two hydraulic actuators (pitch and roll) which maintain the platform level at all times. The block diagram in figure 6-16 shows the complete system interconnected. The stabilized GSI system cannot compensate for a ship's heave. Heave is the rise and fall of the entire ship without a change in pitch or roll angle.



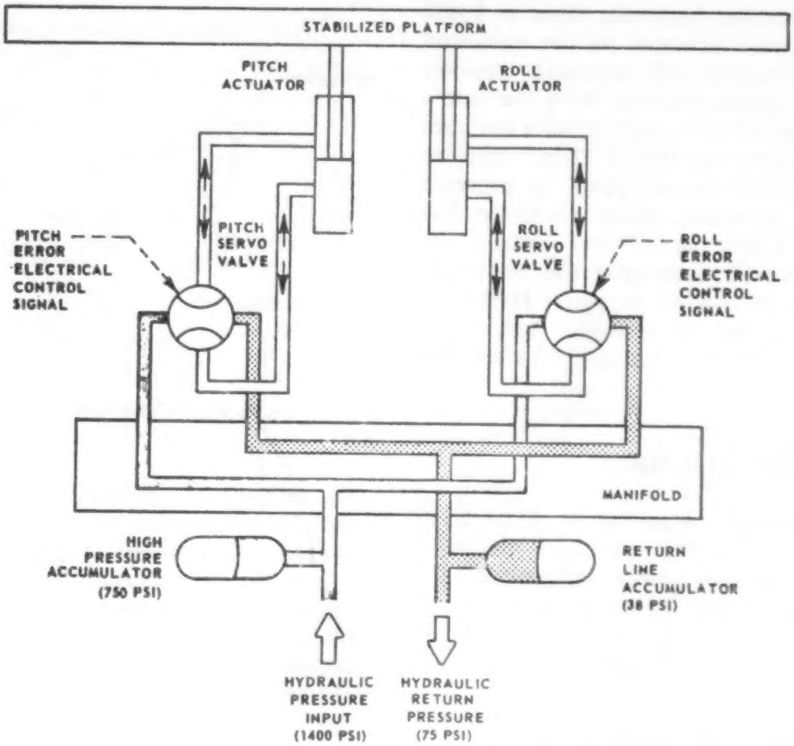
111.184

Figure 6-14.—Stabilized platform assembly.

VERTICAL GYROSCOPE

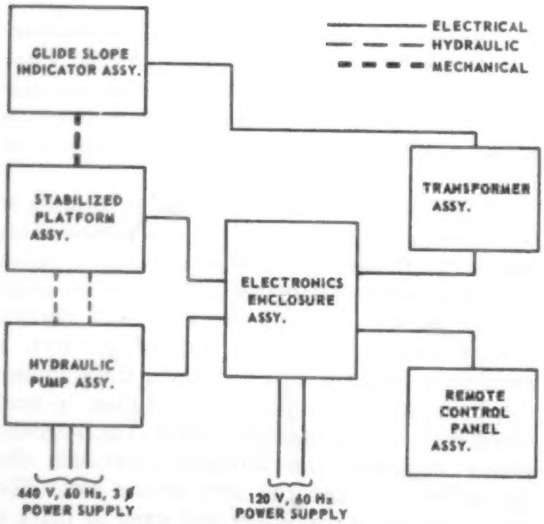
The vertical gyroscope is basically a mechanical device. The essential element of the gyroscope is a flywheel rotating at high angular velocity about an axis. The flywheel is mounted within gimbals which allow it 2 degrees of freedom. (See fig. 6-17.)

When the gyroscope's flywheel is rotating at high speed, its inertia is greatly increased. This causes the flywheel to remain stationary within the gyro gimbal structure. In order to align the gyroscope flywheel to the local earth's gravity vector (downward pull of gravity), a pendulum sensor is attached under the spinning flywheel. In operation, the pendulum is held suspended within a magnetic sensor. The magnetic sensor measures the difference between the pendulum axis and the spin motor axis. The sensor output is amplified and used to drive a torque motor. This motor causes the gyro flywheel to rotate in a direction that reduces the


STABILIZED PLATFORM
PITCH ACTUATOR
ROLL ACTUATOR
PITCH SERVO VALVE
ROLL SERVO VALVE
PITCH ERROR ELECTRICAL CONTROL SIGNAL
ROLL ERROR ELECTRICAL CONTROL SIGNAL
MANIFOLD
HIGH PRESSURE ACCUMULATOR (750 PSI)
RETURN LINE ACCUMULATOR (38 PSI)
HYDRAULIC PRESSURE INPUT (1400 PSI)
HYDRAULIC RETURN PRESSURE (75 PSI)

111.185

Figure 6-15.—Function diagram of the stabilized platform assembly.


ELECTRICAL
HYDRAULIC
MECHANICAL
GLIDE SLOPE INDICATOR ASSY.
STABILIZED PLATFORM ASSY.
HYDRAULIC PUMP ASSY.
ELECTRONICS ENCLOSURE ASSY.
TRANSFORMER ASSY.
REMOTE CONTROL PANEL ASSY.
440 V, 60 Hz, 3 ∅ POWER SUPPLY
120 V, 60 Hz POWER SUPPLY

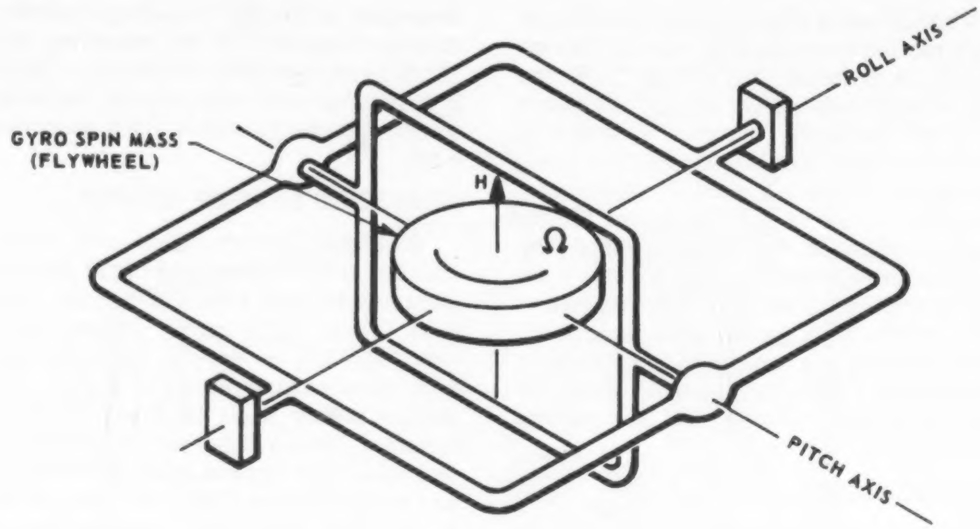
111.186

Figure 6-16.—Stabilized glide slope indicator system—block diagram.

sensor output. In actual operation, the pendulum sensor is affected by lateral accelerations which cause it to oscillate about true position. To correct for this oscillation, the gyro circuit's time constants are long. The long time constants cause the gyro flywheel to ignore periodic variations of the pendulum and align itself to the average pendulum position. Figure 6-18 shows the essential elements of the gyro.

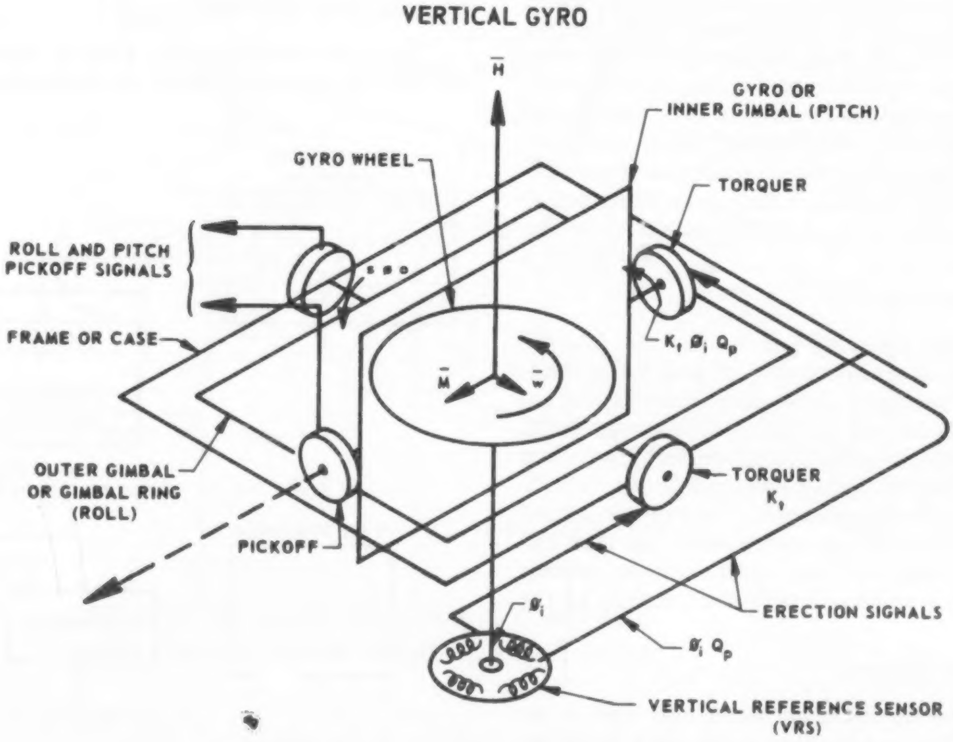
GYRO ALARM CIRCUIT

The stabilized GSI system incorporates an independent failure detection circuit. This detects any failure that results from a loss of stabilization. It does this by comparing an input from the ship's gyro with the output of the platform LVDT. When the system is operating correctly in the internal gyro mode, the output of the LVDT is directly proportional to the ship's motion. If the ship's motion from the


GYRO SPIN MASS
(FLYWHEEL)
H
Ω
ROLL AXIS
PITCH AXIS

111.217

Figure 6-17.—Vertical gyro-simplified schematic.


VERTICAL GYRO
H̄
GYRO OR
INNER GIMBAL (PITCH)
GYRO WHEEL
TORQUER
ROLL AND PITCH
PICKOFF SIGNALS
FRAME OR CASE
K_t Ø_i Q_p
M̄
W̄
OUTER GIMBAL
OR GIMBAL RING
(ROLL)
TORQUER
K_t
PICKOFF
Ø_i
ERECTION SIGNALS
Ø_i Q_p
VERTICAL REFERENCE SENSOR
(VRS)

111.218

Figure 6-18.—Vertical gyro-line schematic diagram.

LVDT is added out of phase (reverse polarity) to the ship's motion from the ship's gyro, the two will cancel. Any remaining voltage from the summation will be the error between the ship's gyro and the platform. The error is compared against a preset limit, and if it exceeds this limit, the platform error relay is tripped. The gyro input is required for the alarm and is also used for the ship's gyro stabilization and for the rate lead. The rate lead circuits are used to reduce velocity lag of the platform and to increase system dynamic accuracy. In the ship's gyro stabilization mode, the system operates at a reduced accuracy because of null errors and LVDT linearity error. Therefore the ship's gyro mode is to be used as a backup mode only.

HOMING BEACON

The homing beacon is a high intensity white lamp located on the mainmast or high on the superstructure. It should be visible for at least 330 degrees in azimuth. The beacon has a minimum effective intensity of 1,500 candles over a span of 7 degrees in elevation and produces approximately 90 flashes per minute. The intensity of the beacon light can be varied from blackout to full intensity by a dimmer control on the lighting control panel. The homing beacon is wired in two circuits; the motor which turns the reflector is wired to a fixed-voltage circuit (115 volts), while the lamp (150 watt) is wired through a step-down transformer (115/32 volts) to a variable voltage dimming circuit.

EDGE LIGHTS

The edge lights outline the periphery of the obstruction-free helicopter deck area with a minimum of four lights along each edge of the area. Edge lights are red omnidirectional lamps which can be seen in any direction above deck level. They are connected to the low voltage side of a 115/12-volt step-down transformer. The 115-volt side of each transformer (one transformer per light fixture) is connected to a motor-driven variable transformer which controls the intensity of the lights.

LINE-UP LIGHTS

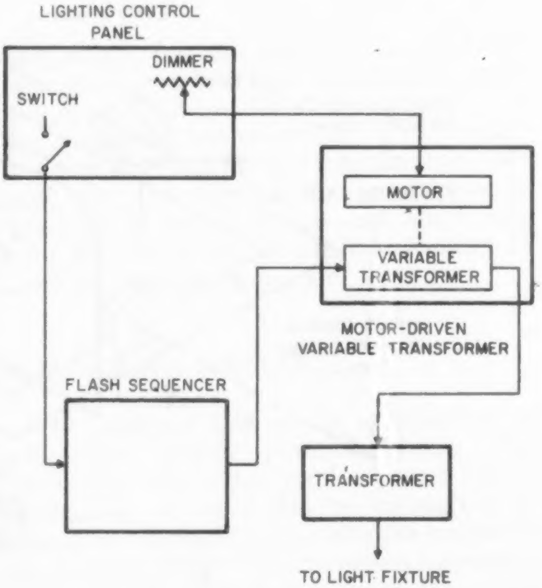
The line-up lights are white and flash in sequence. They are installed in the deck along the line-up line for deck landing. Line-up lights are either unidirectional or bidirectional (LSTs only) dependent on the ship's landing capability. Each lamp is connected to the secondary side of a 115/6.5-volt step-down transformer. The primary is connected to a motor-driven, variable transformer (intensity) and a flash sequencer (fig. 6-19).

EXTENDED LINE-UP LIGHTS

Extended line-up lights are white lights installed at the forward end of the deck-installed line-up lights and extend above the flight-deck level. These lights merely extend the line-up lights forward to provide the helicopter pilot with a better visual picture of line up with information during night landing operations. The extended line-up lights are a minimum of six individual light fixtures either mounted vertically to a bulkhead or on a light bar assembly mounted to the flight deck. Each extended line-up light fixture is connected to a 6.5-volt secondary of a 120/6.5-volt step-down transformer. The primaries of the transformers are connected to the same circuit as the deck-installed, line-up lights.

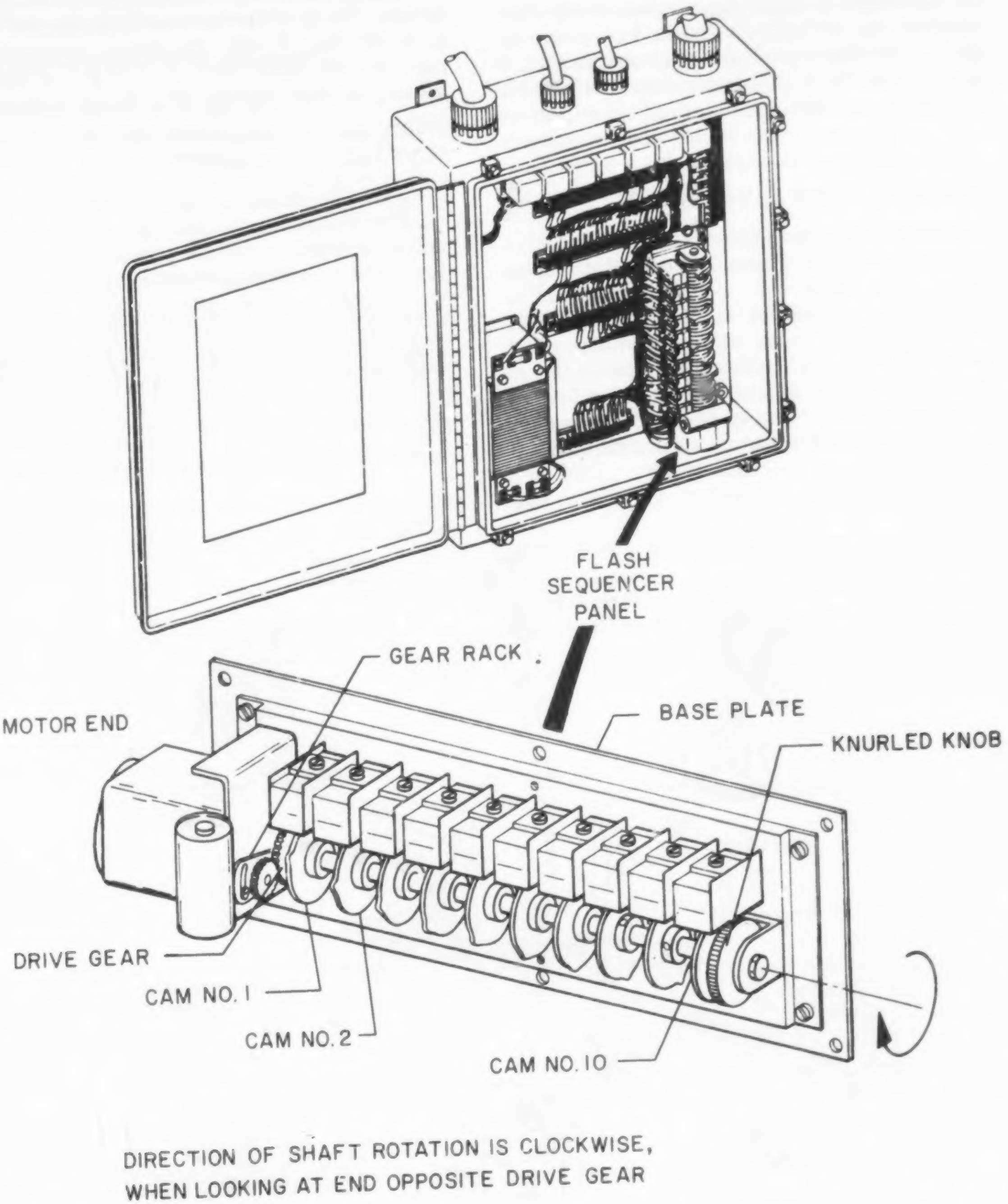
FLASH SEQUENCER

The flash sequencer (fig. 6-20) is wired into the line-up lights to provide the helicopter pilot



111.187

Figure 6-19.—Simplified interconnection of line-up lights.


FLASH SEQUENCER PANEL
GEAR RACK
MOTOR END
BASE PLATE
KNURLED KNOB
DRIVE GEAR
CAM NO. 1
CAM NO. 2
CAM NO. 10
DIRECTION OF SHAFT ROTATION IS CLOCKWISE, WHEN LOOKING AT END OPPOSITE DRIVE GEAR

111.188

Figure 6-20.—Flash sequencer panel and timer assembly.

with additional visual cues and depth perception during night landing approaches. The cam-operated unit sequentially flashes 9 to 10 line-up lights. On ships with both port and starboard approaches, the flash sequencer must be capable of producing flashes (strobing) of either port or starboard line-up lights as selected by controls on the lighting control panel.

VERTICAL DROP-LINE LIGHTS

Vertical drop-line lights are red and serve as an aft extension of the deck-installed line-up lights. The light bar assembly is installed immediately aft of the landing line-up lights and contain four to six red lights which extend below the flight deck in the vertical plane. These lights in conjunction with the extended line-up lights provide the helicopter pilot with continuous line up during night approach when deck-installed line-up lights cannot be seen because of the ship's motion. The drop-line bar assembly operates from a single 120/12-volt step-down transformer/enclosure assembly which is wired to a motor-driven, variable voltage transformer (dimmer).

FORWARD STRUCTURE/DECK SURFACE FLOODLIGHTS

White floodlights, with red filters, are provided to illuminate any structure forward of the landing area and to provide greater depth perception to the pilot during night operations. At least two fixtures, one port and one starboard, must be installed and adjusted to illuminate the aft face of the hangar as well as structures forward of the landing area. Other fixtures are installed and adjusted to illuminate the landing area itself. These fixtures are connected to a motor-driven variable transformer (intensity). Each fixture is

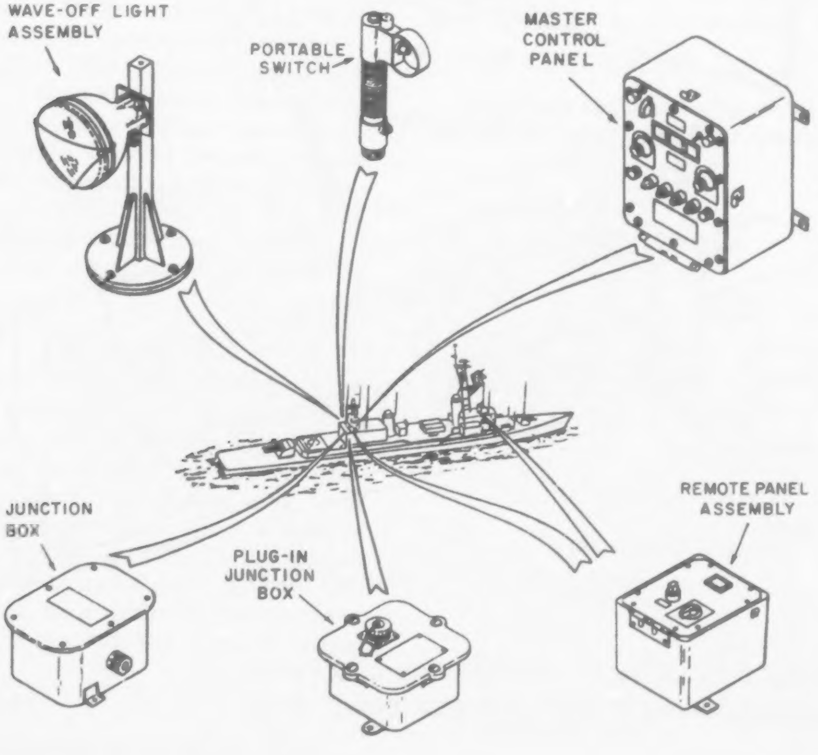


Figure 6-21.—Wave-off light system.

connected to the low voltage side of a separate 120/30-volt step-down transformer.

MAINTENANCE FLOODLIGHTS

Red maintenance floodlights are required for night preflight and postflight maintenance. The floodlight assembly consists of a light fixture, lamp, red filter, on/off switch, and support. The light is wired to the ship's 120-volt, 60-Hz, single-phase power supply.

OVERHEAD FLOODLIGHTS

White overhead floodlights with yellow and red filters provide illumination of the helicopter deck for support of night operations. These lights are mounted above the landing area and are connected to a motor-driven variable transformer.

WAVE-OFF LIGHT SYSTEM

The Wave-Off Light (WOL) System (fig. 6-21) provides a visual cue to the pilot that landing conditions aboard the ship are unacceptable. The system consists of nine major components:

1. Master control panel assembly
2. Two remote panel assemblies
3. Two plug-in junction box assemblies
4. Terminal junction box assembly
5. Two wave-off light assemblies
6. Portable switch

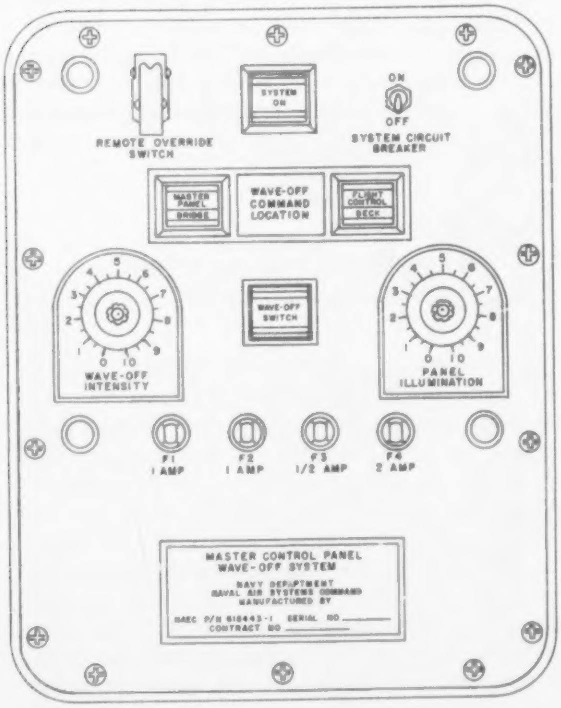
Each of these components is discussed in detail in the following paragraphs.

MASTER CONTROL PANEL

The master control panel (fig. 6-22) is located in the Helicopter Control Station. It controls the power for the WOL, houses the electronic circuitry which controls intensity and flash rate of the WOL, permits operation of the WOL, and indicates which station has control.

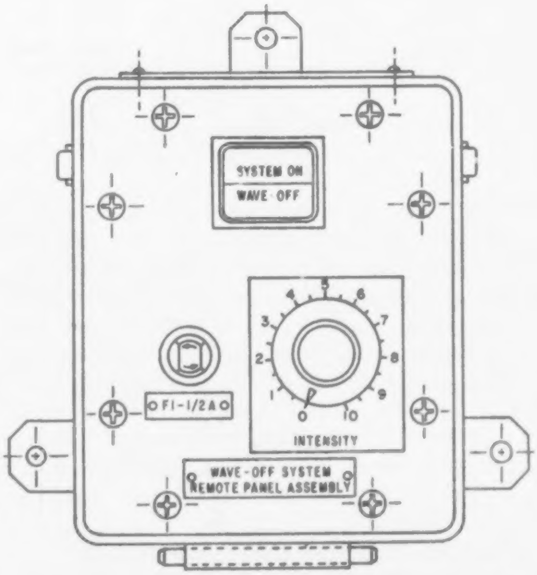
REMOTE PANEL ASSEMBLY

The remote panel assembly (fig. 6-23) allows the WOL to be operated from remote stations


SYSTEM ON
ON
OFF
REMOTE OVERRIDE SWITCH
SYSTEM CIRCUIT BREAKER
MASTER PANEL
BRIDGE
WAVE-OFF COMMAND LOCATION
FLIGHT CONTROL
DECK
WAVE-OFF SWITCH
0 1 2 3 4 5 6 7 8 9 10
WAVE-OFF INTENSITY
PANEL ILLUMINATION
F1 1 AMP
F2 1 AMP
F3 1/2 AMP
F4 2 AMP
MASTER CONTROL PANEL
WAVE-OFF SYSTEM
NAVY DEPARTMENT
NAVAL AIR SYSTEMS COMMAND
MANUFACTURED BY
NAEC P/N 610443-1 SERIAL NO
CONTRACT NO

111.190

Figure 6-22.—Master control panel.


SYSTEM ON
WAVE OFF
F1-1/2A
0 1 2 3 4 5 6 7 8 9 10
INTENSITY
WAVE-OFF SYSTEM
REMOTE PANEL ASSEMBLY

111.191

Figure 6-23.—Remote panel assembly.

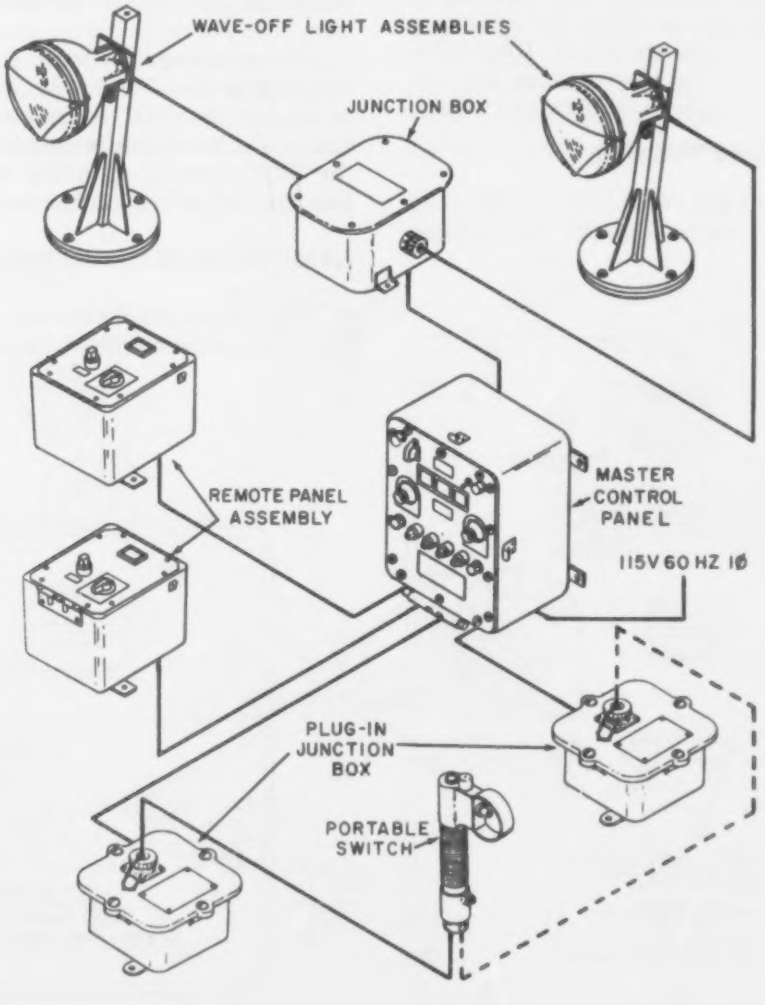
located at the captain's bridge and adjacent to the hangar door.

PLUG-IN JUNCTION BOX ASSEMBLY

Two plug-in junction boxes are contained in one assembly. The junction boxes are located one on either side of the hangar door to permit a plug in of a portable switch to operate the WOL on the flight deck by the landing signalman enlisted (LSE).

TERMINAL JUNCTION BOX ASSEMBLY

The terminal junction box assembly contains the terminals for the connections to the WOL and the master control panel.


WAVE-OFF LIGHT ASSEMBLIES
JUNCTION BOX
REMOTE PANEL ASSEMBLY
MASTER CONTROL PANEL
115V 60 HZ 1Ø
PLUG-IN JUNCTION BOX
PORTABLE SWITCH

111.192

Figure 6-24.—Wave-off light system.

WAVE-OFF LIGHT ASSEMBLY

The wave-off lights are located on each side of the GSI. Figure 6-24 shows interconnection of the WOL system.

HELICOPTER IN-FLIGHT REFUELING LIGHTS (HIFR)

Helicopter in-flight refueling lights are yellow and are required for helicopter refueling operations. These lights give the helicopter pilot a visual indication of the ship's heading at all times and provide a height reference during in-flight refueling operations.

Three yellow HIFR heading lights are installed forward to aft on the port side of the ship in a line parallel to the ship's centerline (heading). Spacing between the lights is approximately 20 feet, beginning outside the rotor clearance distance and extending forward. All HIFR heading lights are installed at the same height, approximately 30 to 40 feet above the ship's waterline. All lights are controlled by a single on/off switch, located on the lighting control panel, and are a standard watertight assembly consisting of a lighting fixture, yellow globe, and a 115-volt, 50-watt rough service lamp.

VERTICAL REPLENISHMENT (VERTREP) LIGHTS

VERTREP line-up lights are bidirectional fixtures for VERTREP/hover approaches, and they form an athwartship line-up path at approximately 8- to 12-foot intervals. Spacing between lights is uniform and such that the pilot's view of the lights is not obstructed during the helicopter's approach. When installed in landing areas equipped with landing approach line-up lights, the VERTREP line-up lights are connected to the same dimmer as the landing approach line-up lights. This switching arrangement prevents the simultaneous energizing of both the landing approach line-up lights and the VERTREP/hover line-up lights.

LIGHTING CONTROL PANEL

The lighting control panel (fig. 6-25) that controls the lights in the VLA package is installed on all ships which conduct helicopter operations at night. This control panel is located at the helicopter control station and consists of switches, dimmers, and red indicator lamps. The dimmers are variable autotransformers mounted in the control panel. The lighting control panel requires input power at 120 volt, 60 Hz and is designed to accommodate the applicable light equipment discussed in the preceding paragraphs. Figure 6-26 is a simplified line diagram of the lighting control panel.

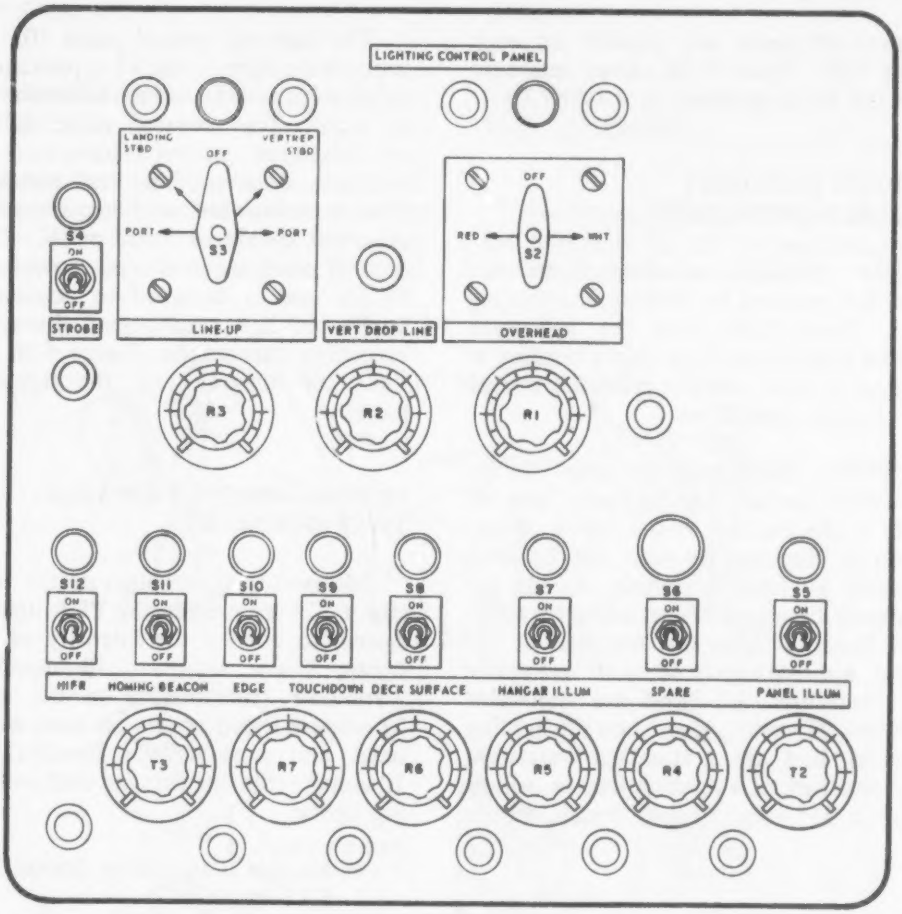
MOTOR-DRIVEN VARIABLE TRANSFORMERS

Motor-driven remote variable transformers (fig. 6-27) are used in the VLA lighting control system to control the intensity of the various lights. There are four 10-ampere and two 22-ampere transformers in the system. The 22-ampere transformers are used with the overhead and deck-surface floodlights and the 10-ampere transformers are used with the following lights:

1. Hangar illumination floodlights
2. Line-up lights
3. Vertical drop-line lights
4. Edge lights

Input power is applied to the variable transformer, and the controlled 0- to 120-volt-a.c. output is connected to the lights (fig. 6-28). The transformer wiper (secondary) is moved by the synchronous motor which is controlled by the potentiometer in the lighting control panel. The detector circuit in the position detector determines from the setting of the remote control potentiometer whether the motor turns in a direction to raise or lower the output voltage.

The reference power supply in the position detector converts a.c. input voltage to d.c., and the potentiometer in the control panel


LIGHTING CONTROL PANEL
LANDING STBD
OFF
VERTREP STBD
PORT
PORT
S3
OFF
RED
WHT
S2
S4
ON
OFF
STROBE
LINE-UP
VERT DROP LINE
OVERHEAD
R3
R2
R1
S12
S11
S10
S9
S8
S7
S6
S5
ON
OFF
HIFR
HOMING BEACON
EDGE
TOUCHDOWN
DECK SURFACE
HANGAR ILLUM
SPARE
PANEL ILLUM
T3
R7
R6
R5
R4
T2

111.193

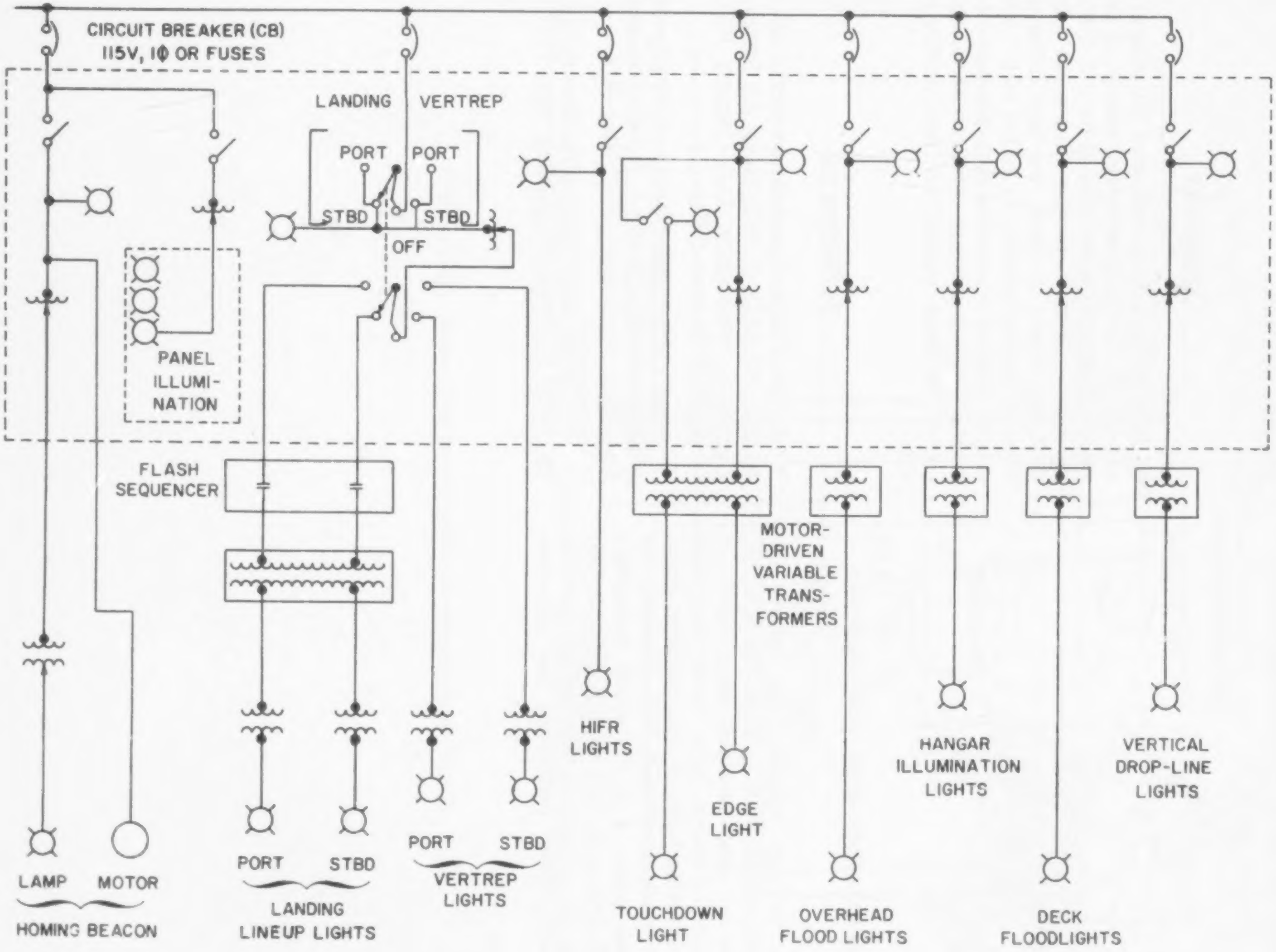
Figure 6-25.—Lighting control panel.

determines the magnitude of d.c. reference voltage sent to the detector circuit. The feedback power supply in the position detector converts the a.c. output voltage from the variable transformer to a proportional d.c. voltage which is also sent to the detector circuit.

The detector circuit consists of a comparator and solid state switches (TRIACS) which energize either the clockwise (LOWER) or counterclockwise (RAISE) windings of the drive motor. The drive motor rotates the wiper shaft on the transformer in the proper direction until the feedback voltage equals the reference, and the motor stops at a position corresponding to the desired light intensity. Cam-operated limit switches open the motor circuit and prevent the motor from driving the wiper on the transformer beyond the upper and lower stops.

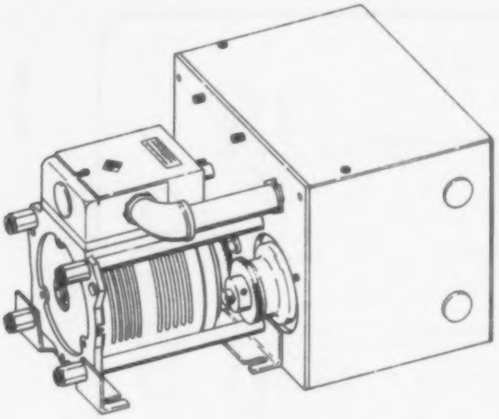
MAINTENANCE REQUIREMENTS

The VLA system contains many electrical and electronic components which require both preventive and corrective maintenance. The components that we have discussed in this chapter contain many motors, controllers, blowers,


CIRCUIT BREAKER (CB)
115V, 1Φ OR FUSES
LANDING
VERTREP
PORT
PORT
STBD
STBD
OFF
PANEL
ILLUMI-
NATION
FLASH
SEQUENCER
MOTOR-
DRIVEN
VARIABLE
TRANS-
FORMERS
HIFR
LIGHTS
EDGE
LIGHT
HANGAR
ILLUMINATION
LIGHTS
VERTICAL
DROP-LINE
LIGHTS
LAMP
MOTOR
HOMING BEACON
PORT
STBD
LANDING
LINEUP LIGHTS
PORT
STBD
VERTREP
LIGHTS
TOUCHDOWN
LIGHT
OVERHEAD
FLOOD LIGHTS
DECK
FLOODLIGHTS

111.194

Figure 6-26.—Simplified line diagram of the lighting control panel.



111.195

Figure 6-27.—Motor-driven variable transformer.

heaters, pressure switches, and lighting fixtures that are exposed to weather. The electronic portions are solid state and are primarily on printed circuit boards. As an Electrician's Mate you can realize some of the problems which will be encountered both with electrical and electronic parts. It is of utmost importance that you follow all PMS requirements carefully to keep all portions of this system operating effectively. When performing any corrective action, always refer to the manufacturer's technical manuals.

SUMMARY

Now that you have completed this chapter, you should have a good comprehension of the various lighting systems installed on U.S. Navy air capable ships. Remember, just as we have different classes of ships, we have different types of lighting systems. As an E-6 or E-7 you may be required to supervise the maintenance of several different systems. Always refer to the correct technical manual for that particular ship.

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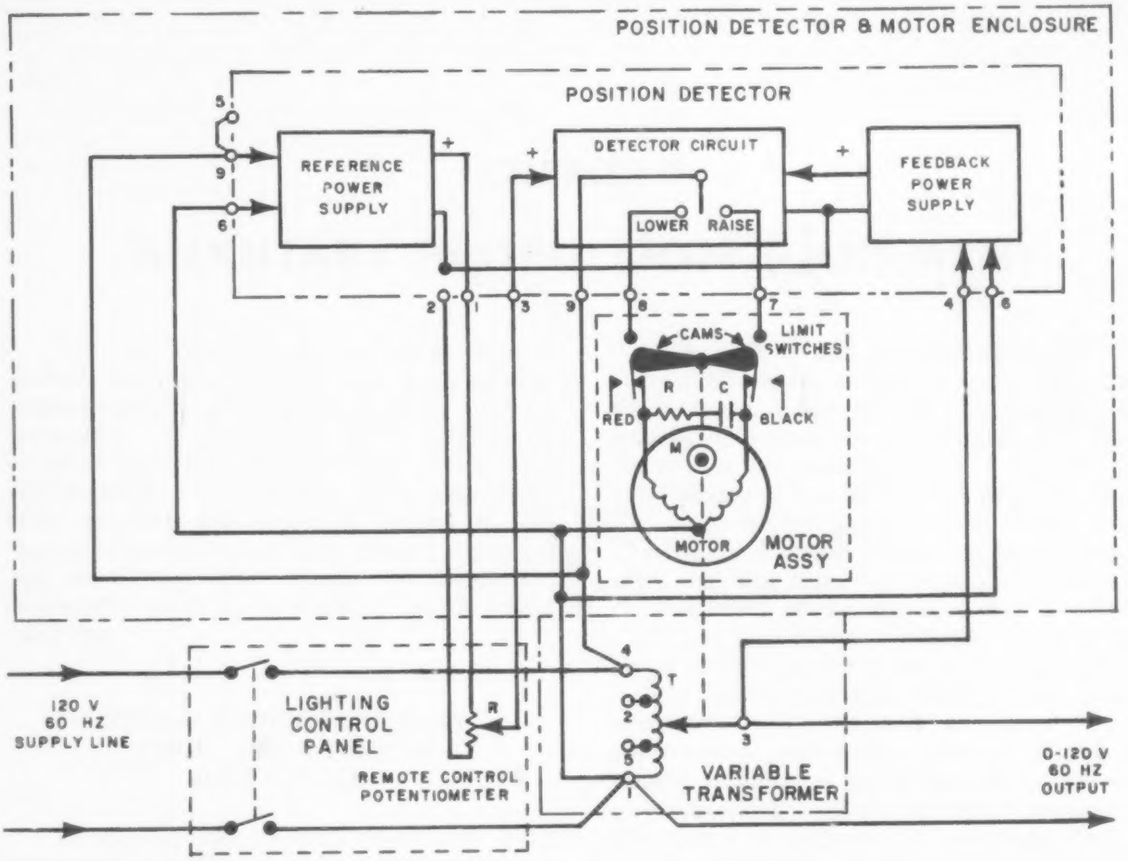
Visual Landing Aids Lighting on Air Capable Ships, NAVAIR 51-50ABA-1, Naval Air Systems Command, Washington, D.C. May 1978

Air Capable Ships Aviation Facilities Bulletin 1E, Naval Air System Command, June 1983


POSITION DETECTOR & MOTOR ENCLOSURE
POSITION DETECTOR
5
9
6
REFERENCE POWER SUPPLY
+
DETECTOR CIRCUIT
+
LOWER
RAISE
+
FEEDBACK POWER SUPPLY
2
1
3
9
8
7
4
6
CAMS
LIMIT SWITCHES
R
C
RED
BLACK
M
MOTOR
MOTOR ASSY
120 V
60 HZ
SUPPLY LINE
LIGHTING CONTROL PANEL
R
REMOTE CONTROL POTENTIOMETER
4
T
2
5
1
3
VARIABLE TRANSFORMER
0-120 V
60 HZ
OUTPUT

111.196

Figure 6-28.—Motor-driven remote variable transformer circuit diagram.

CHAPTER 7

AUXILIARY PROPULSION EQUIPMENT

The fact that the size of naval ships is steadily increasing in both length and width has caused a problem with maneuverability. Auxiliary propulsion equipment has been installed on some of the newer classes of ships to help solve this problem. This equipment assists these ships with entering and departing berths; it also improves the turning ability at sea and eliminates the use of tugs. This chapter will discuss the retractable auxiliary propulsion system found on FFGs.

RETRACTABLE AUXILIARY PROPULSION SYSTEM DESCRIPTION

To explain the auxiliary propulsion (AP) system we will discuss, we have broken it down into three separate sections: auxiliary propulsion motor (APM), training and retracting device (TRD), and controls.

AUXILIARY PROPULSION MOTOR

An auxiliary propulsion motor is mounted on each side of the ship. Each APM is of a special enclosed type design in that the stator is completely enclosed against the entrance of any foreign matter. The stator is made integrally with the housing and, as such, is not accessible for repairs of any nature. The stator coils are wound into the stator laminations, and the entire stator is then hermetically sealed with a special liner. The stator cavity is evacuated of all air and the space filled with epoxy polyester resin. This forms a durable, rigid, and watertight unit.

The rotor is also hermetically sealed with corrosion-resistant material to resist the attack of seawater. After the core laminations are stacked on a mandrel and clamped with studs, the copper bar conductors are driven into the rotor slots and brazed to the copper end rings. The rotor is then shrunk-fit on to the shaft. The outside diameter is then machined, and the rotor enclosing rings and the Inconel rotor liner are assembled on the rotor and shaft assembly. The rotor liner is then welded to the enclosing rings, completing the sealed rotor enclosure.

The housing of the APM is cast nickel-aluminum bronze. It is of extremely durable construction, and many years of service on nuclear submarines has proved the design able to withstand the effects of water immersion, shock, and the pressures of operating depths.

The housing is cooled by means of water flow when it is immersed (fig. 7-1). Three vent holes in the housing are located at the top of the front and rear heads of the motor. Cooling and lubricating water enters these holes at the front of the motor, filling the front-bearing bracket and bearing chamber. The water then completely surrounds the bearings. Water also passes through a hole in the rotor shaft which feeds the lubricating face of the front sleeve bearing. It also passes through the hollow shaft and through the air gap of the motor towards the rear-bearing bracket at the propeller end. The water in the air gap hollow shaft provides a convenient means of absorbing heat. At the propeller end of the motor, water passes through similar passages to surround the thrust and sleeve bearings and cool and lubricate them. The water exits from the motor at the propeller end just in front of the propeller. Water is, therefore, required for proper operation of the APM, and the motor

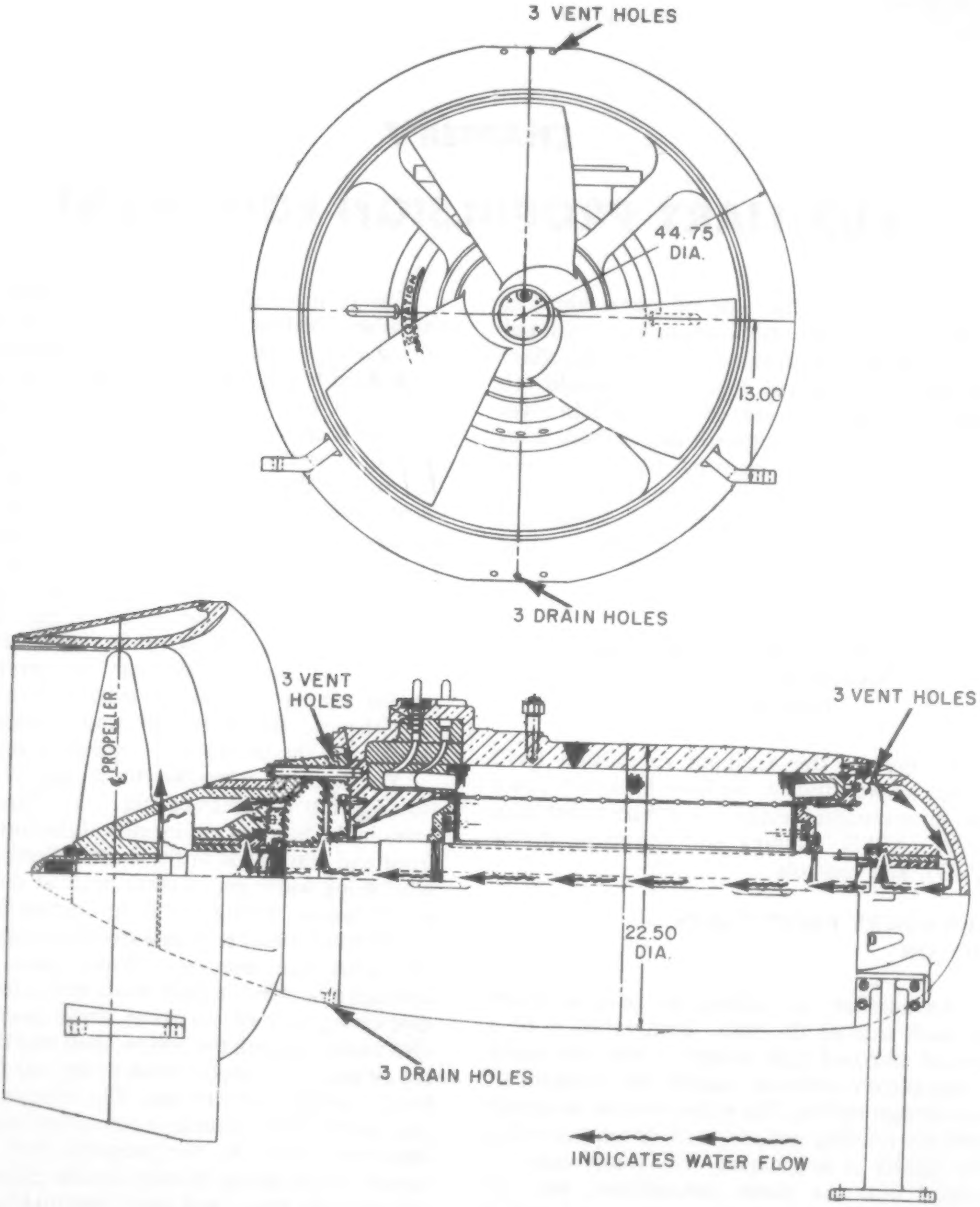

3 VENT HOLES
44.75 DIA.
ROTATION
13.00
3 DRAIN HOLES
3 VENT HOLES
PROPELLER
3 VENT HOLES
22.50 DIA.
3 DRAIN HOLES
INDICATES WATER FLOW

Figure 7-1.—Auxiliary propulsion motor (APM) assembly.

111.219

must never be operated without it. There are no strainers or filters in the vent holes that could become clogged and impair the operation of the motor.

The propeller of the APM is made of cast bronze. It is three-bladed and has a diameter of approximately 36 inches. The pitch of the propeller blades is 22.5 inches at a .7 radius. The propeller is designed for right-hand rotation and to reduce propeller noise. Over 6,500 pounds of thrust is developed by the propeller operating in the *Kort Nozzle* with zero foward velocity of the APM.

TRAINING AND RETRACTING DEVICE

The training and retracting device is the mechanical heart of the auxiliary propulsion system. The yoke assembly contains the gear case that provides for manual or electrical training of the auxiliary propulsion motor. A ball screw drive (fig. 7-2) located on the fore and aft portions of the hull structure acts to raise and lower the upper yoke assembly. The ball screw and ball nut device, two each of which are used to actuate the yoke assembly, is basically identical to a common screw and nut. However, one important difference exists. This difference involves the use of antifriction balls to carry the load across the joint between the nut and screw threads.

These rolling elements greatly reduce the thread friction and provide an efficiency of 90 percent or better. (The best acme or other common power-type thread combination can produce an efficiency no greater than 60 percent.) In this application as the screw rotates, the rotation causes the balls to roll along the thread helix. Pickup fingers remove each ball from near the end of its intended helix portion. Ball guides then return the balls to the start of the helix, which allows the screw to continue. The ball nuts are mounted in a stationary position in the upper yoke, and the vertical motion is provided by rotation of the ball screw. The lower end of the ball screw is retained and rotated by a gear assembly located at the bottom of each ball screw.

Power to this gearing is provided by a retracting motor which is mounted to the

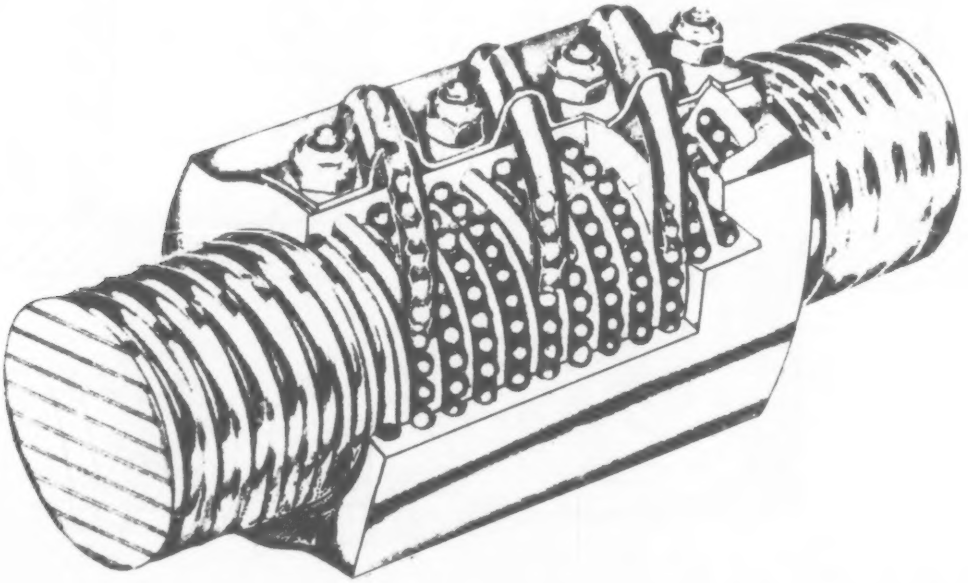
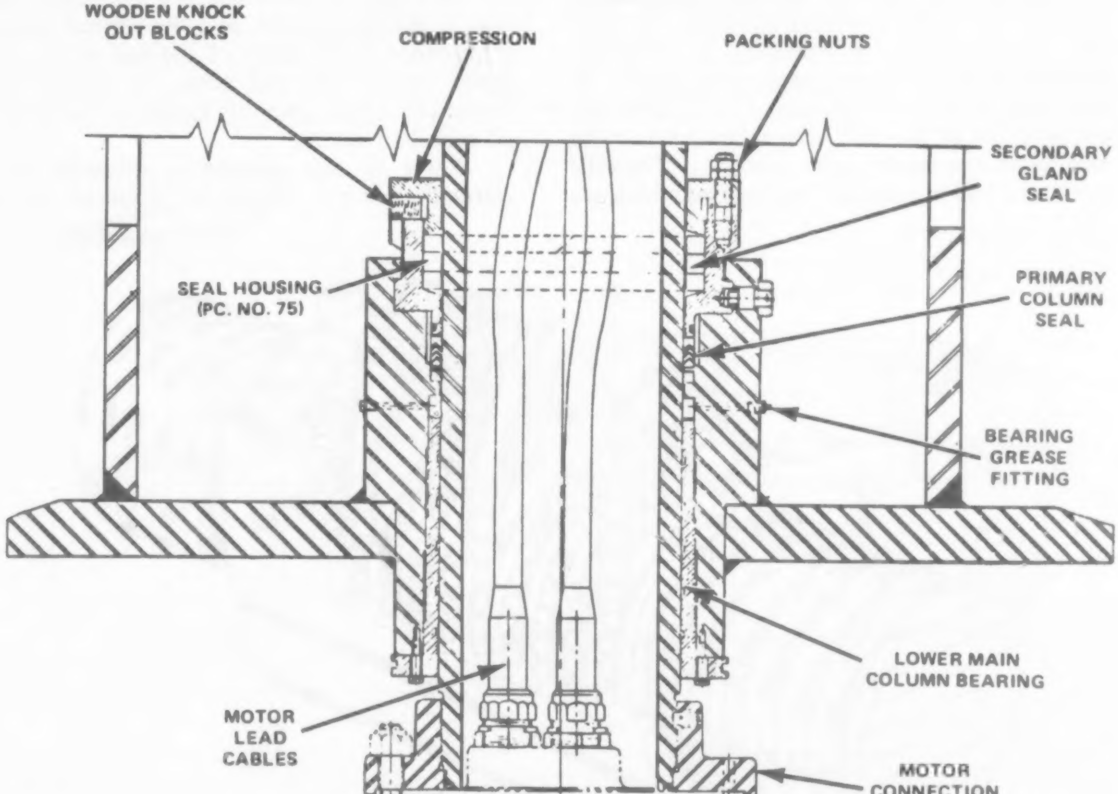


Figure 7-2.—Typical ball screw and nut assembly.

111.220

double-reduction-gear housing and attached to the top of the hull insert. The double-reduction-gear housing is connected to the single-reduction housing by an idler shaft which makes these gear reduction units operate in synchronism to rotate the ball screws and extend or retract the upper yoke. The retracting motor is a 4-horsepower, 450-volt, three-phase, 60-hertz, 1/2-hour duty, squirrel cage motor whose full-load speed is 3,460 rpm. The full-load torque of the motor is approximately 6 foot-pounds. However, this short-time-duty motor is designed to supply approximately 14.5 foot-pounds of torque for the time required to extend or retract the APM. The first gearset in the double-reduction-gear housing provides a 10 to 1 speed reduction through its worm gearset. The second reduction located in the double-reduction-gear housing and the single-reduction-gear housing provides a 7.5 to 1 reduction in speed. Therefore, the overall reduction in speed and torque amplification is approximately 75 to 1. The ball bearing nut and screw arrangement acts as another 2 to 1 reduction and provides 1-inch of travel for each two screw revolutions. When the retracting motor is operating, the brake is released, so the 225 foot-pounds of torque is supplied to each ball screw on a continuous basis or over 540 foot-pounds is supplied to each rod on a short-time basis. Thus, the gearing and ball screw arrangement used to extend or retract the system can generate a vertical force of over


WOODEN KNOCK OUT BLOCKS
COMPRESSION
PACKING NUTS
SECONDARY GLAND SEAL
SEAL HOUSING (PC. NO. 75)
PRIMARY COLUMN SEAL
BEARING GREASE FITTING
LOWER MAIN COLUMN BEARING
MOTOR LEAD CABLES
MOTOR CONNECTION FLANGE

111.221

Figure 7-3.—Lower portion of main column.

100,000 pounds. This is more than sufficient to handle the loads imposed in surface-ship applications.

The training system is powered by a 1-horsepower, 450-volt, 60-hertz, three-phase, 1/2-hour duty squirrel cage motor. This training system is designed to allow continuous rotation in either the clockwise or counterclockwise direction. The training motor is located on the upper yoke and operates through a double-reduction-worm gearing connected directly to the main column. If the training motor is not operative, the training angle can be changed by inserting a crank in the end of the training motor and hand cranking the angle to the desired position. It may be safely operated at any speed up to a maximum of 10 knots.

The top of the main column is interconnected mechanically with the gear casing and yoke assembly, and the auxiliary propulsion motor is flange-mounted to the column. Thus when the main column is raised or lowered, these attached items move up or down as an integral part of the main column. The main column is hollow (fig. 7-3) so that the main power leads from the APM can pass through. At the bottom, these leads are connected to the special studs located in the top of the APM for power connection purposes. The connection at that point also provides a high-pressure water seal so that any water which may enter the column will not cause grounding of the APM. At the top end, the main power leads are connected to similar studs and have a similar water seal. Therefore if, for some reason, the main column would become totally filled with water, the power system would still not be grounded. The electrical studs located near the top of the column pass through a secondary seal. This seal prevents passage of water into the ship's hull should the main column break outside of the hull for any reason. On the other side of the secondary seal, leads are connected to the electrical studs and to the bottom end of the slip ring assembly used to transfer power while the main column is rotating. Special silver graphite brushes designed to carry the high-current density involved are located on the secondary side of the rotating joint. These are connected to the main power lead connection terminals located in the top end of the upper yoke. The slip ring assembly permits the APM to be trained in any direction without power interruption to the main motor.

The training and retracting device is also fitted with limit switches, which actuate appropriate pilot light circuits to indicate gear up and locked, gear down and locked, and gear position for retraction. The retracting motor control circuit is electrically interlocked to prevent retracting the APM when it is not in the zero (0) position. When the APM has been trained to the proper position (zero degrees on the thrust direction indicator) as the position indicator unit (fig. 7-4)

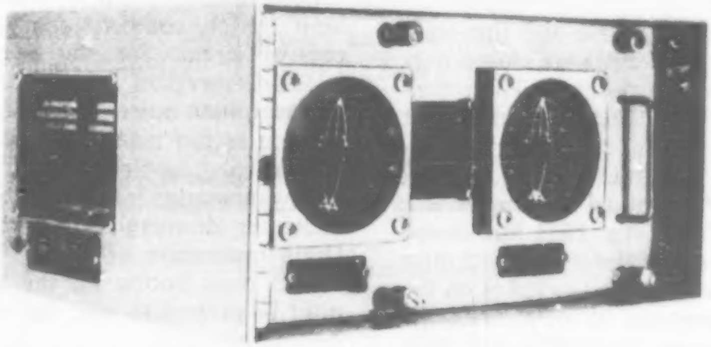


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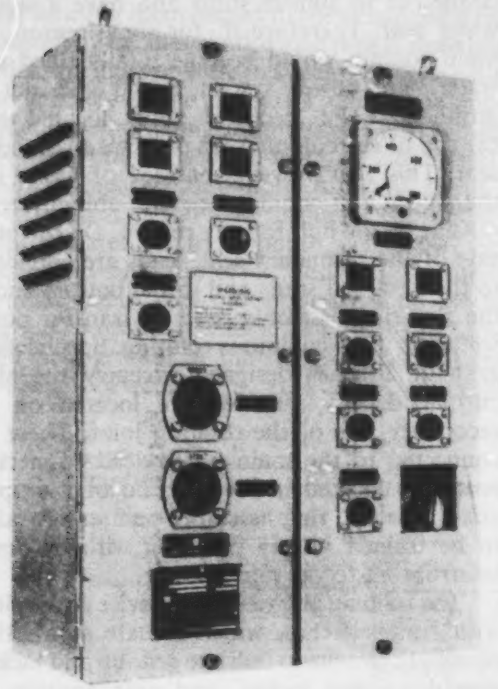
Figure 7-4.—Position indicator.



111.223

Figure 7-5.—Local control box.

at the local control station, the zero position light on the local control box unit (fig. 7-5) will illuminate. This indicates the APM is ready to be retracted.

Contacts of both the coarse and fine train zero limit switches on the TRD are closed only when the APM is in zero position. These contacts are in series with the light, the unit retract push button, and the coil of the retracting contactor in the local control box. In normal electrical operation, the manual retracting crank override limit switch on the TRD has closed contacts also in series with the unit retract push button. The unit retracted limit switches on the TRD have closed contacts in series with the contactor coil whenever the TRD is not fully retracted. The contactor can then be energized by pressing the unit retract, normal open, momentary push button on the local control box which energizes the retracting motor and raises the APM. An interlock contact latches the contactor coil and the motor continues to run until the unit is fully retracted or the hoist stop push button on the local control box is pressed. A safety interlock for manual operation of the retracting motor prevents electrical control of the motor while the manual crank is inserted. The manual training crank override limit switch on the TRD is deactivated when the access cover is raised and the crank is inserted (fig. 7-6). The limit switch contacts open in the electrical control circuit for the retracting contactor which de-energizes the contractor and, in turn, removes input power from the retracting motor as long as the crank remains inserted. If low voltage or complete loss of voltage occurs during operation of the retracting motor, the contactor de-energizes and the motor stops. Upon restoration of normal voltage, the unit retract push button on the local control box must be pressed to start the retracting motor.

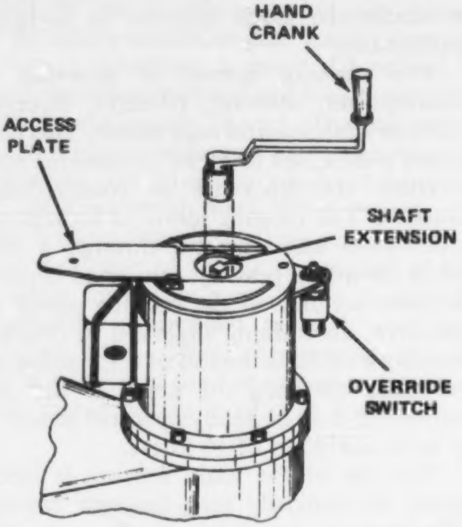


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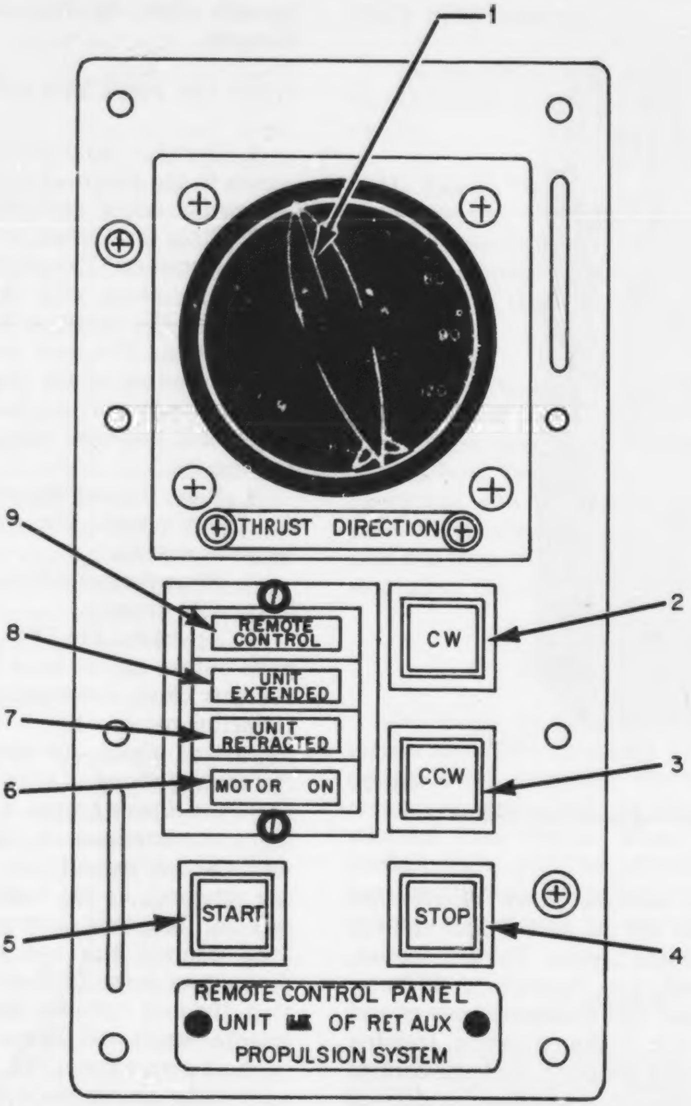
Figure 7-6.—Manual control of training and retracting motor.

CONTROLS

Each control system provides the means for controlling and actuating both the auxiliary


1
THRUST DIRECTION
9
8
7
6
REMOTE CONTROL
UNIT EXTENDED
UNIT RETRACTED
MOTOR ON
CW
2
CCW
3
START
5
STOP
4
REMOTE CONTROL PANEL
UNIT OF RET AUX
PROPULSION SYSTEM

1. **Thrust direction**
2. **Clockwise direction pushbutton**
3. **Counterclockwise direction pushbutton**
4. **Start pushbutton**
5. **Stop pushbutton**
6. **Motor on lamp**
7. **Unit retracted lamp**
8. **Unit extended lamp**
9. **Remote control lamp**

111.225

Figure 7-7.—Remote control panel.

propulsion motor and the training and retracting device (supporting mechanism). As we have discussed, the APM may be raised, lowered, trained, started, and stopped from the local control box (fig. 7-5) or trained, started, and stopped from the remote control panel (fig. 7-7). The position indicator (fig. 7-4) displays the operating position of the port and starboard auxiliary propulsion motors.

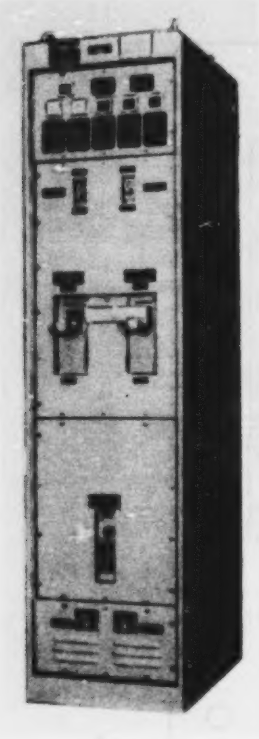


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Figure 7-8.—Electrical power distribution unit.

There are two electrical power distribution units (fig. 7-8), one for the port system and the other for the starboard system. The distribution units receive 450 volts a.c., three-phase, 60-hertz, type I ship's normal and emergency power and provide 450 volts a.c. to the retracting, training or propulsion motors (through the local control boxes), and 110 volts a.c. control power derived from the control transformer. Each unit consists basically of five circuit breakers with fuse-protected light indicators.

OPERATING PROCEDURES

We will now discuss how to turn the unit ON and OFF so that you will better understand the entire system, but first a couple of *warnings*. First, ensure that there is sufficient depth of water under the keel to permit complete extension of the APM and TRD; second, never extend the unit when the ship's speed is greater than 10 knots.

TURN ON PROCEDURE

1. Energize input power from ship's normal service to the electrical power distribution unit, the *normal power available* lamp illuminates.
2. Place the normal power circuit breaker in the ON position. The *main power CB on* lamp illuminates along with the two *unit retracted* lamps and the *zero position* lamp on the local control box. The *unit retracted* lamp on the remote control panel illuminates. The *thrust direction* indicators on both the remote control panel and position indicator should indicate zero position.
3. Place the *training motor circuit breaker* in the ON position. The *training motor CB on* lamp illuminates.
4. Place the *propulsion motor circuit breaker* in the ON position.
5. To extend the TRD, press the *unit extend* push button on the local control box. Its main contacts close, connecting 450 volts a.c to the retracting motor while it is releasing the retracting motor brake. An auxiliary contact latches the contactor coil to keep it energized when the *unit extend* push button is released. The retracting motor continues to run (lowering the TRD) until the unit extend limit switches on the TRD are actuated, or the *hoist stop* push button is pressed. The *unit retracted* lamps on both the local control box and remote control panel de-energize as the TRD extends. Upon full extension, the *unit extended* lamps on both local and remote panels will illuminate.
6. To train the APM, press either the *clockwise* or the *counterclockwise* push button on the local control panel, or if it is in remote, then press the same push buttons on the remote panel. The contactor is energized (closing its main contacts), connecting 450 volts a.c. to the training motor. Both push buttons are momentary, and the training motor should stop upon their release. The position of the APM is displayed by the *thrust direction* indicator and the appropriate remote control panel. Operation of the APM units in opposing thrust directions, such that the water moving through one nozzle impinges on the other nozzle, may cause severe

vibration because of the water action. Never operate both APMs simultaneously at these angles (port APM at 270° angle, starboard APM at 90° angle).

7. To start the APM, press the *start* push button on the local control box. This energizes the closing coil at the auxiliary propulsion motor circuit breaker in the electrical power distribution unit, connecting 450 volts to the APM. An auxiliary contact closes in the circuit breaker lighting the *on* lamp on both the local and the remote panels. A second auxiliary contact closes, lighting the propulsion motor circuit breaker *on* lamp and energizing the *propulsion motor operating time* meter located on the electrical power distribution unit. The *motor current* meter on the local control box should indicate the APM current (540 amp at rated motor current). Excessive jogging of the APM will result in excessive heating and damage to the APM and its circuit breaker. Never exceed three starts in rapid succession or six starts per minute with less than a 5 seconds off period between starts.

TURN OFF PROCEDURE

1. To stop the APM, press the stop push button. This energizes the shunt trip circuit within the auxiliary propulsion motor circuit breaker in the electrical power distribution unit. The breaker opens and disconnects the 450 volts a.c. from the APM. The following indicators will de-energize: *motor current meter*, *propulsion motor CB on* lamp, *propulsion motor operating time* meter, and the *on* lamps at the local and remote panels.
2. Train the APM to zero position utilizing the *clockwise* or *counterclockwise* push buttons on the local control box. When the APM is at zero position, the coarse and fine train zero switches on the TRD should close, and the *zero position* lamp lights.
3. Retract the TRD by pushing the *unit retract* push button. The retracting motor energizes, releasing the break, and raises the TRD. When it is fully retracted, the *unit extended* lights go out, and the *unit retracted* light illuminates.
4. To secure the equipment, place all circuit breakers on the electrical power distribution unit in the *off* positions.

TEST PROCEDURE

The operation of the APM can be tested with the TRD fully retracted by following these procedures:

1. Ensure that all ship's service a.c. inputs are applied to the retractable auxiliary propulsion equipment. Close either the *normal* or *emergency* power circuit breaker.
2. Ensure the TRD is fully retracted as indicated by the *unit retracted* lamp on the local control box.
3. Place the *station mode* selector switch on the local control box to *test*.
4. Press *motor test* push button on the control box. The *on* lamp lights indicate APM operation, and the *motor current meter* indicates APM current. The *motor test* push button is of the momentary type, and the APM should stop upon the release of the push button.

MAINTENANCE

Shipboard maintenance of this electrical system should be throughly covered under your present PMS program. However, you should remember that PMS is based only on the minimal requirements. When this equipment is needed, there could be serious problems if it is not operational, therefore, the importance of maintenance cannot be overemphasized.

SUMMARY

After you have completed this chapter, you should understand the basic functions of the auxiliary propulsion equipment. There are different types in use today in the fleet. However, if you understand this basic system, you should be able to master any of the others. Remember always to refer to the correct and current technical manual before you attempt any repairs or troubleshooting.

REFERENCE

Retractable Auxiliary Propulsion Equipment System, NAVSEA 0963-LP-047-8010

APPENDIX I

TEMPERATURE CONVERSION LIST

Numbers in the center column (between those marked C and F) refer to temperature, either Centigrade or Fahrenheit, which it is desired to convert into the other scale. To convert from Fahrenheit to Centigrade find equivalent temperature in left hand column marked C; in like manner find equivalent temperature in right hand column when converting from Centigrade to Fahrenheit. Example: 50 F. is 10 C.; 50 C. is 122 F.

C.		F.	C.		F.	C.		F.	C.		F.
–12.2	**10**	50.0	4.4	**40**	104.4	21.1	**70**	158.0	37.8	**100**	212.0
–11.7	**11**	51.8	5.0	**41**	105.8	21.7	**71**	159.8	38.9	**102**	215.6
–11.1	**12**	53.6	5.6	**42**	107.6	22.2	**72**	161.6	40.0	**104**	219.2
–10.6	**13**	55.4	6.1	**43**	109.4	22.8	**73**	163.4	41.1	**106**	222.8
–10.0	**14**	57.2	6.7	**44**	111.2	23.3	**74**	165.2	42.2	**108**	226.4
– 9.4	**15**	59.0	7.2	**45**	113.0	23.9	**75**	167.0	43.3	**110**	230.0
– 8.9	**16**	60.8	7.8	**46**	114.8	24.4	**76**	168.8	44.4	**112**	233.6
– 8.3	**17**	62.6	8.3	**47**	116.6	25.0	**77**	170.6	45.6	**114**	237.2
– 7.8	**18**	64.4	8.9	**48**	118.4	25.6	**78**	172.4	46.7	**116**	240.8
– 7.2	**19**	66.2	9.4	**49**	120.2	26.1	**79**	174.2	47.8	**118**	244.4
– 6.7	**20**	68.0	10.0	**50**	122.0	26.7	**80**	176.0	48.9	**120**	248.0
– 6.1	**21**	69.8	10.6	**51**	123.8	27.2	**81**	177.8	50.0	**122**	251.6
– 5.6	**22**	71.6	11.1	**52**	125.6	27.8	**82**	179.6	51.1	**124**	255.2
– 5.0	**23**	73.4	11.7	**53**	127.4	28.3	**83**	181.4	52.2	**126**	258.8
– 4.4	**24**	75.2	12.2	**54**	129.2	28.9	**84**	183.2	53.3	**128**	262.4
– 3.9	**25**	77.0	12.8	**55**	131.0	29.4	**85**	185.0	54.4	**130**	266.0
– 3.3	**26**	78.8	13.3	**56**	132.8	30.0	**86**	186.8	55.6	**132**	269.6
– 2.8	**27**	80.6	13.9	**57**	134.6	30.6	**87**	188.6	56.7	**134**	273.2
– 2.2	**28**	82.4	14.4	**58**	136.4	31.1	**88**	190.4	57.8	**136**	276.8
– 1.7	**29**	84.2	15.0	**59**	138.2	31.7	**89**	192.2	58.9	**138**	280.4
– 1.1	**30**	86.0	15.6	**60**	140.0	32.2	**90**	194.0	60.0	**140**	284.0
– 0.6	**31**	87.8	16.1	**61**	141.8	32.8	**91**	195.8	61.1	**142**	287.6
0.0	**32**	89.6	16.7	**62**	143.6	33.3	**92**	197.6	62.2	**144**	291.2
+ 0.6	**33**	91.4	17.2	**63**	145.4	33.9	**93**	199.4	63.3	**146**	294.8
1.1	**34**	93.2	17.8	**64**	147.2	34.4	**94**	201.2	64.4	**148**	298.4
1.7	**35**	95.0	18.3	**65**	149.0	35.0	**95**	203.0			
2.2	**36**	96.8	18.9	**66**	150.8	35.6	**96**	204.8			
2.8	**37**	98.6	19.4	**67**	152.6	36.1	**97**	206.6			
3.3	**38**	100.4	20.0	**68**	154.4	36.7	**98**	208.4			
3.9	**39**	102.2	20.6	**69**	156.2	37.2	**99**	210.2			

APPENDIX II

THE METRIC SYSTEM

The metric system was developed by French scientists in 1790 and was specifically designed to be an easily used system of weights and measures to benefit science, industry, and commerce. The metric system is calculated entirely in powers of 10, so one need not work with the various mathematical bases used with the English system, such as 12 inches to a foot, 3 feet to a yard, and 5,280 feet to a mile.

The system is based on the meter which is one ten-millionth of the distance from the equator to the north pole. It is possible to develop worldwide standards from this base of measurement. The metric system of weights is based on the gram, which is the weight of a specific quantity of water.

Soon after the system was developed, scientists over the world adopted it and were able to deal with the mathematics of their experiments more easily. The data and particulars of their work could be understood by other scientists anywhere in the world. During the early nineteenth century, many European nations adopted the new system for engineering and commerce. It was possible for these countries to trade manufactured goods with one another without worrying whether it would be possible to repair machinery from another country without also buying special wrenches and measuring tools. Countries could buy and sell machine tools and other sophisticated and precision machinery without troublesome modifications or alterations. It was much easier to teach the metric system, since meters can be changed to kilometers or centimeters with the movement of a decimal point, which is roughly like being able to convert yards to miles or inches by adding zeros and a decimal instead of multiplying by 1,760 or dividing by 36.

With the exception of the United States, all the industrialized nations of the world have adopted the metric system. Even England and Canada have changed from their traditional systems of measure, and the metric system has been almost universal since 1980.

Although the metric system has not been officially legislated by the Congress, the metric system is becoming more prominent in this country. Most automobile mechanics own some metric wrenches to work on foreign cars or foreign components in American cars. Almost all photographic equipment is built to metric standards. Chemicals and drugs are usually sold in metric quantities, and calorie counters are using a metric unit of thermal energy.

Because we are allied with countries who use the metric system, much of our military information is in metric terms. Military maps use meters and kilometers instead of miles, and many weapons are in metric sizes, such as 7.62 mm, 20 mm, 40 mm, 75 mm, and 155 mm. Interchange of military equipment has caused a mixture of metric and English measure equipment since World War I when the army adopted the French 75-mm field gun, and World War II when the Navy procured the Swedish 40-mm Bofors and the Swiss 20-mm Oerlikon heavy machine guns.

It is inevitable that the United States will officially adopt the metric system. Exactly when this happens and how rapidly the changeover will depend on economics, since the expense of retooling our industry and commerce to new measurements will be very great. The cost of conversion will be offset by increased earnings from selling machinery and products overseas. Another benefit is that scientists use the metric system, but their calculations now have to be translated into English measure to be used by industry. With adoption of the metric system, ideas can go directly from the drawing board to the assembly line.

The Navy will be using the metric system more during the next few years. Although you will find it easier to solve problems using this system, at first you will find it difficult to visualize or to estimate quantities in unfamiliar units of measure.

Fortunately, many metric units can be related to equivalent units in the English system.

The meter, which is the basic unit, is approximately one-tenth longer than a yard.

The basic unit of volume, the liter, is approximately 1 quart. The gram is the weight of a cubic centimeter, or milliliter, of pure water and is the basic unit of weight. As a common weight though, the kilogram, or kilo, which equals the weight of a liter of water, weighs 2.2 pounds. The cubic centimeter (cc) is used where we would use the square inch, and where we measure by the fluid ounce, the metric system uses the milliliter (ml). For power measure the metric system uses the kilowatt (kW), which is approximately 1.3 horsepower.

In terms of distance, a land mile is eight-fifths of a kilometer and a nautical mile is 1.852 kilometers, or nearly 2 kilometers.

A basic metric expression of pressure is the kilogram per square centimeter, which is 14.2 psi, nearly 1 atmosphere of pressure.

When working on foreign machinery, you may notice that your 1/2-inch, 3/4-inch, and 1-inch wrenches will fit many of the bolts. These sizes correspond to 13 mm, 19 mm, and 26 mm respectively in the metric system and are very popular because they are interchangeable. The 13/16-inch spark plug wrench, which is standard in this country, is intended to fit a 20-mm nut.

The basic quantities of the metric system are multiplied or divided by powers of 10 to give other workable values. We cannot easily measure machine parts in terms of a meter, so the millimeter, or one-thousandth of a meter, is used. For very fine measure, the micron, also called the micrometer, can be used. It is one-millionth part of a meter, or one-thousandth of a millimeter. For small weights the milligram, one-thousandth of a gram, is used. All of these multiples are expressed with standard prefixes taken from Latin.

micro = 1/1,000,000

milli = 1/1,000

centi = 1/100

*deci = 1/10

*deca = 10

*hecto = 100

kilo = 1,000

*myria = 10,000

mega = 1,000,000

*Rarely used

Over the next few years, the metric system will become more used by the Navy as well as by the civilian world. You will find it easy to work with once you have mastered the basic terms. It will be difficult to translate values from our present system to the metric system, but this operation will become unnecessary once the new measurements are totally adopted.

Tables of equivalent English measure and metric equivalents are essential when you work simultaneously with both systems. The table which follows shows the equivalent measures of the two systems. The columns on the left have the equivalent values which are accurate enough for most work, and on the right are the multiples used to convert the values with a high degree of accuracy.

METRIC CONVERSION

CONVERSION OF INCHES TO MILLIMETERS

Inches	Millimeters	Inches	Millimeters	Inches	Millimeters
0.001	0.025	0.290	7.37	0.660	16.76
0.002	0.051	0.300	7.62	0.670	17.02
0.003	0.076	0.310	7.87	0.680	17.27
0.004	0.102	0.320	8.13	0.690	17.53
0.005	0.127	0.330	8.38	0.700	17.78
0.006	0.152	0.340	8.64	0.710	18.03
0.007	0.178	0.350	8.89	0.720	18.29
0.008	0.203	0.360	9.14	0.730	18.54
0.009	0.229	0.370	9.40	0.740	18.80
0.010	0.254	0.380	9.65	0.750	19.05
0.020	0.508	0.390	9.91	0.760	19.30
0.030	0.762	0.400	10.16	0.770	19.56
0.040	1.016	0.410	10.41	0.780	19.81
0.050	1.270	0.420	10.67	0.790	20.07
0.060	1.524	0.430	10.92	0.800	20.32
0.070	1.778	0.440	11.18	0.310	20.57
0.080	2.032	0.450	11.43	0.820	20.83
0.090	2.286	0.460	11.68	0.830	21.08
0.100	2.540	0.470	11.94	0.840	21.34
0.110	2.794	0.480	12.19	0.850	21.59
0.120	3.048	0.490	12.45	0.860	21.84
0.130	3.302	0.500	12.70	0.870	22.10
0.140	3.56	0.510	12.95	0.880	22.35
0.150	3.81	0.520	13.21	0.890	22.61
0.160	4.06	0.530	13.46	0.900	22.86
0.170	4.32	0.540	13.72	0.910	23.11
0.180	4.57	0.550	13.97	0.920	23.37
0.190	4.83	0.560	14.22	0.930	23.62
0.200	5.08	0.570	14.48	0.940	23.88
0.210	5.33	0.580	14.73	0.950	24.13
0.220	5.59	0.590	14.99	0.960	24.38
0.230	5.84	0.600	15.24	0.970	24.64
0.240	6.10	0.610	15.49	0.980	24.89
0.250	6.35	0.620	15.75	0.990	25.15
0.260	6.60	0.630	16.00	1.000	25.40
0.270	6.86	0.640	16.26	....	....
0.280	7.11	0.650	16.51	....	....

CONVERSION OF MILLIMETERS TO INCHES

Millimeters	Inches	Millimeters	Inches	Millimeters	Inches
0.01	0.0004	0.35	0.0138	0.68	0.0268
0.02	0.0008	0.36	0.0142	0.69	0.0272
0.03	0.0012	0.37	0.0146	0.70	0.0276
0.04	0.0016	0.38	0.0150	0.71	0.0280
0.05	0.0020	0.39	0.0154	0.72	0.0283
0.06	0.0024	0.40	0.0157	0.73	0.0287
0.07	0.0028	0.41	0.0161	0.74	0.0291
0.08	0.0031	0.42	0.0165	0.75	0.0295
0.09	0.0035	0.43	0.0169	0.76	0.0299
0.10	0.0039	0.44	0.0173	0.77	0.0303
0.11	0.0043	0.45	0.0177	0.78	0.0307
0.12	0.0047	0.46	0.0181	0.79	0.0311
0.13	0.0051	0.47	0.0185	0.80	0.0315
0.14	0.0055	0.48	0.0189	0.81	0.0319
0.15	0.0059	0.49	0.0193	0.82	0.0323
0.16	0.0063	0.50	0.0197	0.83	0.0327
0.17	0.0067	0.51	0.0201	0.84	0.0331
0.18	0.0071	0.52	0.0205	0.85	0.0335
0.19	0.0075	0.53	0.0209	0.86	0.0339
0.20	0.0079	0.54	0.0213	0.87	0.0343
0.21	0.0083	0.55	0.0217	0.88	0.0346
0.22	0.0087	0.56	0.0220	0.89	0.0350
0.23	0.0091	0.57	0.0224	0.90	0.0354
0.24	0.0094	0.58	0.0228	0.91	0.0358
0.25	0.0098	0.59	0.0232	0.92	0.0362
0.26	0.0102	0.60	0.0236	0.93	0.0366
0.27	0.0106	0.61	0.0240	0.94	0.0370
0.28	0.0110	0.62	0.0244	0.95	0.0374
0.29	0.0114	0.63	0.0248	0.96	0.0378
0.30	0.0118	0.64	0.0252	0.97	0.0382
0.31	0.0122	0.65	0.0256	0.98	0.0386
0.32	0.0126	0.66	0.0260	0.99	0.0390
0.33	0.0130	0.67	0.0264	1.00	0.0394
0.34	0.0134	...	.....	...	.....

INDEX

A

Acceptance trials and inspections, 2-10 to 2-11
AC/DC electric propulsion operating records, 1-6
Actuator control, 5-18
Additional records, 1-11 to 1-14
Administration, supervision, and training, 1-1 to 1-34
    additional records, 1-11 to 1-14
        degaussing folder, 1-14
        engineering officer's night order book, 1-11
        gas turbine service records, 1-14
        gyrocompass service record, 1-14
        situation reports, 1-14
        steaming orders, 1-11 to 1-14
    disposal of engineering records and reports, 1-14 to 1-16
    legal engineering records, 1-2 to 1-6
        engineering log, 1-2 to 1-5
        Engineer's Bell Book, 1-5 to 1-6
    operating records, 1-6 to 1-11
        AC/DC electric propulsion operating record, 1-6
        electric log, 1-6
        fuel and water reports, 1-6
        gyrocompass operating record, 1-6
        IC room operating record, 1-11
        monthly summary, 1-6
    operation responsibilities, 1-1 to 1-2
    references, 1-34
    training, 1-16 to 1-34
        training programs, 1-17 to 1-19
            apprenticeship training, 1-19
            military training, 1-17
            professional training, 1-17 to 1-19
Administration, supervision, and training—Continued
    training—Continued
        training records, 1-19 to 1-34
            group, 1-19 to 1-33
            Personnel Advancement Requirements (PARs), 1-33 to 1-34
            Personnel Qualification Standards (PQS), 1-34
Administrative inspections, 2-1 to 2-4
Amplidyne exciter, 4-8 to 4-9
Amplifier, 5-24
Analysis and reports, 2-9 to 2-10
Analysis of the battle problem, 2-5 to 2-7
Apprenticeship training, 1-19
Assembly of records and reports, 2-8 to 2-9
Automatic voltage regulator, 4-20 to 4-25
Auxiliary propulsion equipment, 7-1 to 7-9
    maintenance, 7-9
    operating procedures, 7-8 to 7-9
        turn off procedure, 7-9
        turn on procedure, 7-8 to 7-9
    reference, 7-9
    retractable auxiliary propulsion system description, 7-1 to 7-8
        auxiliary propulsion motor, 7-1 to 7-3
        controls, 7-6 to 7-8
        training and retracting device, 7-3 to 7-6
    summary, 7-9

B

Battle casualties, 3-22
Battle problems, 2-4
Board of inspection and survey inspection, 2-10 to 2-11

C

Casualty control board, 3-14
Casualty correction, 3-12 to 3-24
Casualty prevention, 3-1 to 3-12
Checkoff lists, administrative inspection, 2-2 to 2-4
Condition sheets, 2-8
Conduct of a battle problem, 2-5
Control console casualty, 3-22
Control element, 4-4 to 4-6
Control section, 5-22 to 5-23
Controls, 7-6 to 7-8
Cross-current compensator, 4-6

D

Damaged cable and equipment, 3-22
Damping transformer, 4-5 to 4-6
Degaussing folder, 1-14
Detailed circuit description, 5-23 to 5-31
Diesel electric d.c. drive (fleet tug) casualties, 3-21 to 3-22
Direct acting rheostat voltage regulator, 4-2 to 4-7
Disposal of engineering records and reports, 1-14 to 1-16

E

ECCET (engineering casualty control evaluation team), 3-2 to 3-3
Edge lights, 6-14
EGB-2P governor/actuator, 5-15 to 5-20
EG-M control box, 5-10 to 5-13
EG-M system, 5-2 to 5-15
EG-R hydraulic actuator, 5-4 to 5-7
Electric log, 1-6
Electric plant casualties, 3-20 to 3-21
Electrical fires, 3-21
Electrical inspections, 2-18
Electronic enclosure assembly, 6-4 to 6-7
Electrohydraulic load-sensing speed governors, 5-1 to 5-33
  EGB-2P governor/actuator, 5-15 to 5-20
    maintenance, 5-20
    operation, 5-16 to 5-20
      actuator control, 5-18
      governor control, 5-18 to 5-19
      speed droop, 5-19 to 5-20

Electrohydraulic load-sensing speed governors—Continued
  EG-M system, 5-2 to 5-15
    maintenance, 5-14 to 5-15
    operation, 5-4 to 5-14
      EG-M control box, 5-10 to 5-13
      EG-R hydraulic actuator, 5-4 to 5-7
      hydraulic amplifier, 5-7 to 5-10
      load signal box, 5-13 to 5-14
  references, 5-32
  summary, 5-32
  2301 electric governor, 5-20 to 5-32
    detailed circuit description, 5-23 to 5-31
      amplifier, 5-24
      input voltage distribution, 5-23 to 5-24
      load sensor, 5-27 to 5-31
      ramp generator, 5-24 to 5-25
      speed sensor, 5-25 to 5-27
      speed setting reference voltage, 5-24
    maintenance, 5-31 to 5-32
    operation, 5-20 to 5-23
      control section, 5-22 to 5-23
      input section, 5-22
Engine room casualties, 3-19 to 3-20
Engineering casualty control, 3-1 to 3-24
  casualty correction, 3-12 to 3-24
    battle casualties, 3-22
    casualty control organization, 3-12 to 3-15
      casualty control board, 3-14
      engineering officer of the watch, 3-12 to 3-13
      repair party, 3-14 to 3-15
      watch teams, 3-13 to 3-14
    casualty power system, 3-22 to 3-24
    damaged cable and equipment, 3-22
    diesel electric d.c. drive (fleet tug) casualties, 3-21 to 3-22
      control console casualty, 3-22
      propulsion generator casualty, 3-21 to 3-22
    electric plant casualties, 3-20 to 3-21
      electrical fires, 3-21
      loss of lube oil, 3-21
      overload generator, 3-21

Engineering casualty control—Continued,
  casualty correction—Continued
    engine room casualties, 3-19 to 3-20
      excessive vibration of shaft, 3-19 to 3-20
      loss of lube oil, 3-20
      vibration of turbine, 3-20
    fireroom casualties, 3-15 to 3-19
      failure of forced draft blower, 3-18 to 3-19
      high water, 3-15 to 3-18
      loss of fuel oil suction, 3-19
      low water, 3-18
    marine gas turbine drive casualties, 3-24
  casualty prevention, 3-1 to 3-12
    ECCET (engineering casualty control evaluation teams), 3-2 to 3-3
    engineering operational sequencing system (EOSS), 3-3 to 3-12
      engineering operational casualty control (EOCC), 3-9 to 3-12
      engineering operational procedures (EOP), 3-5 to 3-9
      EOSS User's Guide, 3-5
  references, 3-24
  summary, 3-24
Engineering department inspection, 2-2
Engineering log, 1-2 to 1-5
Engineering officer of the watch, 3-12 to 3-13
Engineering officer's night order book, 1-11
Engineering operational sequencing system (EOSS), 3-3 to 3-12
Engineer's Bell Book, 1-5 to 1-6
Estimating work, 2-20 to 2-21
Excessive vibration of shaft, 3-19 to 3-20
Extended line-up lights, 6-14

F

Failure of forced draft blower, 3-18 to 3-19
Feedback form, 2-21
Fireroom casualties, 3-15 to 3-19
Flash sequencer, 6-14 to 6-16
Forward structure/deck surface floodlights, 6-16 to 6-17
Frequency difference monitoring circuit, 4-35 to 4-39
Fuel and water reports, 1-6
Fuel oil suction, loss of, 3-19
Full power and economy trials, 2-11 to 2-12

G

Gas turbine service records, 1-14
General inspection of the ship as a whole, 2-1 to 2-2
General rules for trials, 2-12
Glide slope indicator (GSI), 6-11
Governor control, 5-18 to 5-19
Gyro alarm circuit, 6-12 to 6-14
Gyrocompass operating record, 1-6
Gyrocompass service record, 1-14

H

Hearing conservation program, 2-14 to 2-15
Helicopter in-flight refueling lights (HIFR), 6-19
High water, 3-15 to 3-18
Homing beacon, 6-14
Hydraulic amplifier, 5-7 to 5-10
Hydraulic pump assembly, 6-9 to 6-11

I

IC room operating record, 1-11
Indirect acting rheostatic voltage regulator, 4-2
Input section, 5-22
Input voltage distribution, 5-23 to 5-24
Inspections and maintenance, 2-1 to 2-22
  administrative inspections, 2-1 to 2-4
    administrative inspection checkoff lists, 2-2 to 2-4
    engineering department inspection, 2-2
    general inspection of the ship as a whole, 2-1 to 2-2
    inspecting party, 2-1
  board of inspection and survey inspection, 2-10 to 2-11
    acceptance trials and inspections, 2-10 to 2-11
    material inspections made by the board, 2-10
    survey of ships, 2-11

Inspections and maintenance—Continued
  Maintenance and Material Management Systems (3-M Systems), 2-18 to 2-21
    estimating work, 2-20 to 2-21
    feedback form, 2-21
    Planned Maintenance Schedules, 2-18 to 2-19
      cycle schedule, 2-19
      quarterly schedule, 2-19
      weekly schedule, 2-19
    scheduling work, 2-19 to 2-20
  material inspection, 2-7 to 2-10
    analysis and reports, 2-9 to 2-10
    assembly of records and reports, 2-8 to 2-9
    condition sheets, 2-8
    conduct of the inspection, 2-9
    opening machinery for inspection, 2-8
    preparation for the material inspection, 2-7 to 2-8
  noise pollution inspections, 2-14 to 2-17
    hearing conservation program, 2-14 to 2-15
    responsibilities, 2-15
      Chief, Naval Education and Training, the, 2-15
      Chief of Naval Material, 2-15
      Commander, Naval Safety Center, 2-16
      Engineer Officer, 2-16 to 2-17
      Fleet Commander in Chief, 2-16
      Naval Inspector General, 2-15
      Naval Medical Command (BUMED), 2-15
      President, Board of Inspection and Survey, 2-16
      Work Center Supervisor, 2-17
  operational readiness inspection, 2-4 to 2-7
    analysis of the battle problem, 2-5 to 2-7
    battle problems, 2-4
    conduct of a battle problem, 2-5
    observing party, 2-4
    preparation of a battle problem, 2-4 to 2-5
  quality assurance program, 2-17 to 2-18
    electrical inspections, 2-18
    ship quality control inspectors, 2-17 to 2-18

Inspections and maintenance—Continued
  references, 2-22
  ship trials, 2-11 to 2-14
    full power and economy trials, 2-11 to 2-12
    general rules for trials, 2-12
    inspections and tests before trials, 2-12
    manner of conducting trials, 2-13 to 2-14
    observation of trials, 2-13
    postrepair trial, 2-11
    trial requirements, 2-12 to 2-13
    underway report data, 2-12
  summary, 2-21 to 2-22

L

Legal engineering records, 1-2 to 1-6
Lighting control panel, 6-19
Line-up lights, 6-14
Load signal box, 5-13 to 5-14
Local sensor, 5-27 to 5-31
Loss of lube oil, 3-20, 3-21
Low water, 3-18

M

Maintenance and Material Management Systems (3-M Systems), 2-18 to 2-21
Maintenance, auxiliary propulsion equipment, 7-9
Maintenance floodlights, 6-17
Manner of conducting trials, 2-13 to 2-14
Marine gas turbine drive casualties, 3-24
Master control panel, 6-17
Material inspections made by the board, 2-10
Material inspection, 2-7 to 2-10
Metric system, the, AII-1 to AII-3
Military training, 1-17
Monthly summary, 1-6
Motor-driven variable transformer, 6-19 to 6-20

N

Noise pollution inspections, 2-14 to 2-17

O

Observation of trials, 2-13
Observing party, 2-4
Opening machinery for inspection, 2-8
Operating procedures, auxiliary propulsion equipment, 7-8 to 7-9
Operating records, 1-6 to 1-11
Operation responsibilities, 1-1 to 1-2
Operational readiness inspections, 2-4 to 2-7
Organization, casualty control, 3-12 to 3-15
Output circuit, 4-29 to 4-31
Overhead floodlights, 6-17
Overload generator, 3-21

P

Personnel Advancement Requirements (PARs), 1-33 to 1-34
Personnel Qualification Standards (PQS), 1-34
Phase difference monitoring circuit, 4-31 to 4-33
Pilot alternator, 4-9
Planned Maintenance Schedules, 2-18 to 2-19
Plug-in junction box assembly, 6-18
Postrepair trials, 2-11
Power system, casualty, 3-22 to 3-24
Preparation of a battle problem, 2-4 to 2-5
Professional training, 1-17 to 1-19
Propulsion generator casualty, 3-21 to 3-22
Propulsion motor, auxiliary, 7-1 to 7-3

Q

Quality assurance program, 2-17 to 2-18

R

Ramp generator, 5-24 to 5-25
Records, training, 1-19 to 1-34
References, 1-34, 2-22, 3-24, 4-39, 5-32, 6-22, 7-9
Remote control panel assembly, 6-9
Remote panel assembly, 6-17 to 6-18
Repair party, 3-14 to 3-15
Retractable auxiliary propulsion system description, 7-1 to 7-8
Rotary amplifier and voltage regulation system, 4-16 to 4-27

S

Scheduling work, 2-19 to 2-20
Servicing techniques for transistorized circuits, 4-39
Ship quality control inspectors, 2-17 to 2-18
Ship trials, 2-11 to 2-14
Situation reports, 1-14
Speed droop, 5-19 to 5-20
Speed sensor, 5-25 to 5-27
Speed setting reference voltage, 5-24
SPR-400 line voltage regulator, 4-27 to 4-28
Stabilized glide slope indicator system, 6-1 to 6-19
Stabilizer, 4-9
Standardized platform assembly, 6-11
Static exciter, 4-19 to 4-20
Steaming orders, 1-11 to 1-14
Survey of ships, 2-11
Synchronizing monitor, 4-28 to 4-39

T

Temperature conversion list, AI-1
Terminal junction box assembly, 6-18
2301 electric governor, 5-20 to 5-32
Training, 1-16 to 1-34
Training and retracting device, 7-3 to 7-6
Transformer assembly, 6-11
Trial requirements, 2-12 to 2-13
Turn off procedure, 7-9
Turn on procedure, 7-8 to 7-9
Types of voltage regulators, 4-1 to 4-28

U

Underway report data, 2-12

V

Vertical drop-line lights, 6-16
Vertical gyroscope, 6-11 to 6-12
Vertical replenishment (VERTREP) lights, 6-19 to 6-22
Vibration of turbine, 3-20

- Visual landing aids, 6-1 to 6-23
  - references, 6-22
  - stabilized glide slope indicator system, 6-1 to 6-19
    - edge lights, 6-14
    - electronic enclosure assembly, 6-4 to 6-9
    - extended line-up lights, 6-14
    - flash sequencer, 6-14 to 6-16
    - forward structure/deck surface floodlights, 6-16 to 6-17
    - glide slope indicator (GSI), 6-11
    - gyro alarm circuit, 6-12 to 6-14
    - helicopter in-flight refueling lights (HIFR), 6-19
    - homing beacon, 6-14
    - hydraulic pump assembly, 6-9 to 6-11
    - line-up lights, 6-14
    - maintenance floodlights, 6-17
    - master control panel, 6-17
    - overhead floodlights, 6-17
    - plug-in junction box assembly, 6-18
    - remote control panel assembly, 6-9
    - remote panel assembly, 6-17 to 6-18
    - standardized platform assembly, 6-11
    - terminal junction box assembly, 6-18
    - transformer assembly, 6-11
    - vertical drop-line lights, 6-16
    - vertical gyroscope, 6-11 to 6-12
    - wave-off light assembly, 6-19
    - wave-off light system, 6-17
  - summary, 6-22
  - vertical replenishment (VERTREP) lights, 6-19 to 6-22
    - lighting control panel, 6-19
    - maintenance requirements, 6-20 to 6-22
    - motor-driven variable transformer, 6-19 to 6-20
- Voltage and frequency regulation, 4-1 to 4-39
  - references, 4-39
  - servicing techniques for transistorized circuits, 4-39
  - summary, 4-39
  - synchronizing monitor, 4-28 to 4-39
    - frequency difference monitoring circuit, 4-35 to 4-39
    - output circuit, 4-29 to 4-31
    - phase difference monitoring circuit, 4-31 to 4-33
    - voltage difference monitoring circuit, 4-33 to 4-35
- Voltage and frequency regulation—Continued
  - types I, II, and III power, 4-1
  - types of voltage regulators, 4-1 to 4-28
    - direct acting rheostat voltage regulator, 4-2 to 4-7
      - control element, 4-4 to 4-5
      - cross-current compensator, 4-6
      - damping transformer, 4-5 to 4-6
      - maintenance, 4-7
      - operation, 4-6 to 4-7
    - indirect acting rheostatic voltage regulator, 4-2
    - rotary amplifier voltage regulator, 4-7 to 4-16
      - amplidyne exciter, 4-8 to 4-9
      - automatic control circuit, 4-10 to 4-11
      - automatic control unit, 4-10
      - frequency compensation, 4-12 to 4-13
      - maintenance, 4-16
      - manual control circuit, 4-14
      - manual control unit, 4-10
      - operation, 4-14 to 4-16
      - pilot alternator, 4-9
      - potential unit, 4-10
      - reactive compensation, 4-13 to 4-14
      - stabilizer, 4-9
      - three-phase response circuit, 4-12
      - voltage-adjusting unit, 4-9 to 4-10
    - SPR-400 line voltage regulator, 4-27 to 4-28
      - maintenance, 4-28
      - operation, 4-27 to 4-28
    - static excitation and voltage regulation system, 4-16 to 4-27
      - automatic operation, 4-25
      - automatic voltage regulator, 4-20 to 4-25
      - maintenance, 4-25 to 4-27
      - manual operation, 4-25
      - static exciter, 4-19 to 4-20
- Voltage difference monitoring circuit, 4-33 to 4-35

W

- Watch teams, 3-13 to 3-14
- Wave-off light assembly, 6-19
- Wave-off light system, 6-17

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Your Nonresident Career Course (NRCC) contains a set of assignments and answer sheets. You participate in the NRCC for credit by reviewing the learning objectives, studying the text, and answering the questions.

In most cases your NRCC will be administered by your command. In special cases, the NRCC will be administered by the Naval Education and Training Program Development Center. Your ESO will determine who administers your course. No matter who administers your course, you can complete it successfully by earning a grade of at least 3.2 on each assignment. If you receive an assignment grade of less than 3.2, you will be required to repeat the assignment on a resubmit answer sheet.

It is recommended that you complete assignments as quickly as possible to derive maximum benefit from the course. You must complete at least one assignment per month to meet the requirements established by the Chief of Naval Education and Training.

After completion of the course, you may keep the RTM and assignments. Return them only in the event you disenroll or otherwise fail to complete the course. Directions for returning the course materials are given on the disenrollment form in the back of this NRCC.

BLACK DOT INFORMATION

A black dot (●) is used throughout the course to identify supplemental information or instructions for answering certain questions. You should read these black dot entries carefully; they will assist you in answering the questions and/or understanding the material in the text.

HOW TO COMPLETE THIS COURSE SUCCESSFULLY

You should study the RTM before attempting to answer the questions in the course. The RTM pages that you study are listed at the beginning of each assignment. Pay close attention to tables and illustrations as they contain information which will help you to understand the text. You should read the learning objectives provided in the text at the beginning of each chapter or topic or in the course preceding each set of questions. The learning objectives tell you what you should be able to do after studying the RTM. Answering the questions correctly should help you accomplish the objectives.

After studying the text, you should be ready to answer the questions in the assignment. Read each question carefully. Select the BEST ANSWER for each question based on your understanding of the content of the RTM. You may discuss difficult points in the course with others. However, the answer you select must be your own.

Using the appropriate answer sheet, write in the proper assignment number. Ensure the heading information is correctly filled out on the conventional answer sheets, which are located in the back of the course. In the case of the Automatic Data Processing answer sheet, be sure that the information is correctly entered in the appropriate spaces.

You are prohibited from referring to or copying the solutions of others and from giving completed solutions or answers to anyone else. Noncompliance can result in suspension from the course by the administering activity and disciplinary action by Commander Naval Military Personnel Command.

WHEN YOUR COURSE IS ADMINISTERED BY YOUR LOCAL COMMAND

As soon as you have finished an assignment, submit the completed answer sheet to your Educational Services Officer for grading. The graded answer sheet will not be returned to you.

After submitting all required answer sheets and achieving at least a 3.2 grade on each assignment, your command will make the necessary entry in your service record, giving you credit for your work. Letters of satisfactory completion are not issued by the Naval Education and Training Program Development Center for command administered courses.

If you are completing this NRCC to become eligible to take the fleetwide advancement examination, be sure to follow a schedule that will enable you to complete all assignments in time. Your schedule should call for the completion of at least one assignment per month.

WHEN YOUR COURSE IS ADMINISTERED BY THE NAVAL EDUCATION AND TRAINING PROGRAM DEVELOPMENT CENTER

If you have been enrolled in this course with the Naval Education and Training Program Development Center, your course will be administered through the Automatic Data Processing System (ADP). You have been provided ADP-type answer sheets to submit in lieu of the conventional answer sheets contained in the back of this course. The ADP answer sheets must be used and may not be duplicated.

Your answer sheets will not be returned. However, you will be notified which questions were missed. In the event your score is less than 3.2 for an assignment, you will be sent a resubmit answer sheet to complete.

As you complete each assignment, mail the completed ADP answer sheet to the Naval Education and Training Program Development Center where it will be graded. Make sure all the required information on each ADP answer sheet is filled in. Unless you furnish all the information required you may not receive credit for your work.

The Naval Education and Training Program Development Center will issue you a letter of satisfactory completion to certify successful completion of the course (or a creditable unit of the course). To receive a course completion letter, follow the directions given on the course completion form in the back of this NRCC.

NOTE: DO NOT USE THE COURSE COMMENTS PAGE AS THE ENVELOPE FOR RETURNING ANSWER SHEETS OR COURSE MATERIALS.

Envelopes and packing materials for returning answer sheets and course materials should be obtained locally.

RETURN YOUR ADP ANSWER SHEETS TO:

Commanding Officer
Naval Education and Training Program
Development Center, Code 324
Pensacola, FL 32559-5000

Questions concerning the courses administered by NAVEDTRAPRODEVCEN should be referred to the above address or by telephone: AUTOVON 922-1343, FTS 948-1343, or commercial (904) 452-1343.

NAVAL RESERVE RETIREMENT CREDIT

This course is evaluated at 12 Naval Reserve retirement points. These points are creditable to personnel eligible to receive them under current directives governing retirement of Naval Reserve Personnel. Points will be credited upon satisfactory completion of the entire course. Naval Reserve retirement credit will not be given if the student has previously received credit for any Electrician's Mate 1 & C, NRCC or ECC.

COURSE OBJECTIVES

When you complete this course, you will be able to supervise an electrical gang to ensure that safe practices are a way of life aboard ship. You will be able to point out to your junior petty officers the operating principles of voltage regulators, transistorized control devices, electrohydraulic load-sensing speed governors, and visual landing aids. In addition, you will be able to help them troubleshoot and maintain these systems using the appropriate technical manual as a guide. You will also be able to brief your personnel on the details of maintenance administration as well as to guide them through the many inspections for shipboard personnel.

Naval courses may include several types of questions—multiple-choice, true-false, matching, etc. The questions are not grouped by type but by subject matter. They are presented in the same general sequence as the textbook material upon which they are based. This presentation is designed to preserve continuity of thought, permitting step-by-step development of ideas. Not all courses use all of the types of questions available. The student can readily identify the type of each question, and the action required, by inspection of the samples given below.

MULTIPLE-CHOICE QUESTIONS

Each question contains several alternatives, one of which provides the best answer to the question. Select the best alternative, and blacken the appropriate box on the answer sheet.

SAMPLE

s-1. Who was the first person appointed Secretary of Defense under the National Security Act of 1947?

1. George Marshall
2. James Forrestal
3. Chester Nimitz
4. William Halsey

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-1	☐	■	☐	☐	- - -

TRUE-FALSE QUESTIONS

Mark each statement true or false as indicated below. If any part of the statement is false the statement is to be considered false. Make the decision, and blacken the appropriate box on the answer sheet.

SAMPLE

s-2. All naval officers are authorized to correspond officially with any systems command of the Department of the Navy without their respective commanding officer's endorsement.

1. True
2. False

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-2	☐	■	☐	☐	- - -

MATCHING QUESTIONS

Each set of questions consists of two columns, each listing words, phrases or sentences. The task is to select the item in column B which is the best match for the item in column A that is being considered. Items in column B may be used once, more than once, or not at all. Specific instructions are given with each set of questions. Select the numbers identifying the answers and blacken the appropriate boxes on the answer sheet.

SAMPLE

In questions s-3 through s-6, match the name of the shipboard officer in column A by selecting from column B the name of the department in which the officer functions. Some responses may be used once, more than once, or not at all.

A. OFFICER

s-3. Damage Control Assistant

s-4. CIC Officer

s-5. Disbursing Officer

s-6. Communications Officer

B. DEPARTMENT

1. Operations Department
2. Engineering Department
3. Supply Department

Indicate in this way on the answer sheet:

	1 T	2 F	3	4	
s-3	☐	■	☐	☐	- - -
s-4	■	☐	☐	☐	- - -
s-5	☐	☐	■	☐	- - -
s-6	■	☐	☐	☐	- - -

Assignment 1

Administration, Supervision, and Training: Inspections and Maintenance

Textbook Assignment: Pages 1-1 through 1-35 and 2-1 through 2-2

In this course you will demonstrate that learning has taken place by correctly answering training items. The mere physical act of indicating a choice on an answer sheet is not in itself important; it is the mental achievement, in whatever form it may take, prior to the physical act that is important and toward which correspondence course learning objectives are directed. The selection of the correct choice for a correspondence course training item indicates that you have fulfilled, at least in part, the stated objective(s).

The accomplishment of certain objectives, for example, a physical act such as drafting a memo, cannot readily be determined by means of objective type correspondence course items; however, you can demonstrate by means of answers to training items that you have acquired the requisite knowledge to perform the physical act. The accomplishment of certain other learning objectives, for example, the mental acts of comparing, recognizing, evaluating, choosing, selecting, etc., may be readily demonstrated in a correspondence course by indicating the correct answers to training items.

The comprehensive objective for this course has already been given. It states the purpose of the course in terms of what you will be able to do as you complete the course.

The detailed objectives in each assignment state what you should accomplish as you progress through the course. They may appear singly or in clusters of closely related objectives, as appropriate; they are followed by items which will enable you to indicate your accomplishment.

All objectives in this course are learning objectives and items are teaching items. They point out important things, they assist in learning, and they should enable you to do a better job for the Navy.

This self-study course is only one part of the total Navy training program; by its very nature it can take you only part of the way to a training goal. Practical experience, schools, selected reading, and the desire to accomplish are also necessary to round out a fully meaningful training program.

Learning Objective: Recognize some of the increased responsibilities related to advancement and point out some of the practices that should be followed when training personnel.

1-1. With each advancement, you must accept an increased responsibility in military matters only.

1. True
2. False

1-2. As an EM1 or EMC you may be required to perform which of the following assignments?

1. Maintenance and repair of machinery
2. Planning and organizing work details
3. Training and supervising lower rates
4. All of the above

1-3. The duties required of an EM1 or EMC may include which of the following actions?

1. Instructing watch standers in the performance of their duties
2. Ensuring that safety precautions are posted in conspicuous places
3. Familiarization with equipment used by all other engineering ratings
4. All of the above

1-4. Reports regarding administration, maintenance, and repair of naval ships are prescribed by directives from which of the following officials/offices?

1. Type commander
2. Naval Ships Systems Command
3. Chief of Naval Operations
4. All of the above

Learning Objective: Recognize the importance of operating records and reports and indicate factors affecting their maintenance and disposal.

1-5. Standard Engineering Forms are listed in what Navy Stock List of Publications and Forms?

1. NAVSUP 2002
2. NAVSUP 2012
3. NAVSUP 2020
4. NAVSUP 2040

1-6. The Engineering Log and the Engineer's Bell Book are legal records.

1. True
2. False

1-7. Which of the following information is NOT an entry in the Engineering Log?

1. Changes in operation of main machinery and key auxiliaries
2. Mileage steamed for the day and fuel expended
3. Major speed changes and average hourly rpm
4. Minor speed changes and hourly reading of boiler steam pressures and temperatures

1-8. Which of the following officers must approve and sign the Engineering Log Book on the last calendar day of each month?

1. Engineer officer
2. Engineering duty officer
3. Commanding officer
4. Executive officer

1-9. Pages of the Engineering Log are numbered consecutively with a new series of page numbers commencing with the first day of each month.

1. True
2. False

1-10. Who is responsible for making the entries in the Bell Book?

1. Throttleman
2. Helmsman
3. Chief engineer
4. Officer of the deck

1-11. Neat corrections and erasures are permitted in the Engineer's Bell book if they are made only by the person required to sign the record for the watch and if the change is neatly initialed in the margin of the page.

1. True
2. False

1-12. Ships with controlled reversible pitch propellers must record in the Engineer's Bell Book any signalled speed changes by noting the shaft counter readings.

1. True
2. False

1-13. By whom and under what conditions is the Engineer's Bell Book maintained aboard a ship equipped with controllable reversible pitch propellers and with engines that are directly controlled from either the engineroom or the bridge?

1. By bridge personnel at all times
2. By engine room personnel at all times
3. By bridge personnel when engines are directly controlled from the bridge and by engine room personnel at all other times
4. By engine room personnel when engines are directly controlled from the bridge and by bridge personnel at all other times

1-14. When is the fuel and water report submitted to the commanding officer?

1. Daily
2. Weekly
3. Monthly
4. 24 hours prior to leaving port

1-15. After the Monthly Summary has been prepared, who must verify the amount of fuel received for the month?

1. The commanding officer
2. The supply officer
3. The type commander
4. The engineer officer

1-16. Which of the following statements is true regarding a ship's Monthly Summary for a given month?

1. The commanding officer signs the copy which goes to the type commander
2. The engineer officer signs the copy which goes to the files of the engineering department
3. The original is forwarded to the fleet commander by the fifth of the next month
4. The hours-not-underway entries are made on the back of the report

1-17. Where may you find additional information regarding the use of definitions and explanations in the preparation of the Monthly Summary?

1. OPNAVINST 5213.7
2. NWIP 10-1 (revised)
3. Fleet Commander's Instructions
4. OPNAVINST 3540.1

1-18. On the AC/DC Electric Propulsion Operating Record, who enters the remarks and signs the record?

1. Leading Electrician's Mate
2. Electrical officer
3. Electrician's Mate of the Watch
4. Engineer officer

1-19. On a turbo-electric generator plant, the entries in the electrical log concerning the prime mover is usually recorded by a/an

1. Electrician's Mate
2. Engineman
3. Machinist's Mate
4. Machinery Repairman

1-20. On small ships, the Gyrocompass Operating Record and the I.C. Room Operating Record may be maintained on the same form.

1. True
2. False

1-21. Which of the following is/are the purpose(s) of maintaining and retaining engineering operating records and reports?

1. Inform responsible personnel of coming events
2. Supply data for the analysis of equipment
3. Warn of impending casualties
4. All of the above

1-22. The engineer officer's Night Order Book contains both special and standing instructions for the night engineering officer of the watch and is maintained in port and at sea.

1. True
2. False

1-23. The instructions concerning the content of both the Steaming Orders and the Night Order Book are written by the commanding officer of the ship.

1. True
2. False

1-24. Which of the following personnel are required to know the content of the Night Orders?

1. The leading duty petty officer of each engineering division, when in port
2. The oil king
3. The principal watch supervisor of engineering department for both at-sea and inport watches
4. Each of the above

1-25. Early posting of steaming orders is essential to getting a ship with a large engineering plant underway with a minimum of confusion.

1. True
2. False

1-26. Gyrocompass Service Record Books are furnished to each ship by the type commander.

1. True
2. False

1-27. Where are the complete instructions for maintaining the Gyrocompass Service Record Book kept?

1. NAVSEA, chapter 320
2. NAVSEA, chapter 400
3. Engineering Operational Orders
4. Gyrocompass Service Record Book

1-28. Which of the following information may be found in the ship's degaussing folder?

1. Description of installation
2. Inspections, test, and repairs
3. Record of degaussing range runs
4. All of the above

1-29. Who is responsible for keeping the degaussing folder?

1. Electrical officer
2. Engineer officer
3. Log room yeoman
4. Navigator

1-30. Situation reports (SITREPS) are one time reports required in certain situations?

1. True
2. False

1-31. Information about engineering records that must be kept permanently is contained in which of the following publications?

1. Naval Ships' Technical Manual
2. SECNAVINST P5212.5
3. NAVSHIPS 5083
4. NAVSHIPS 3648

1-32. The Engineering Log must be retained aboard ship for a period of how many years?

1. 1 yr
2. 2 yr
3. 3 yr
4. 4 yr

1-33. When the Engineering Log or the Engineer's Bell Book are demanded by a Navy court, photostat copies are made and certified as true copies by the engineer officer for presentation to the court.

1. True
2. False

1-34. What disposition is made of a ship's Engineer's Bell Book if the ship is scrapped?

1. It is scrapped
2. It is sent to the nearest Naval Records Management Center
3. It is sent to NAVSHIPS
4. It is sent to BUDOCKS

1-35. A NAVSEA report that has served its purpose and is no longer useful may be destroyed after how many months?

1. 1 month
2. 12 months
3. 3 months
4. 24 months

Learning Objective: Identify some of the correct procedures used to train personnel properly.

1-36. Technical competence is NOT a requirement in order to teach others.

1. True
2. False

1-37. Each person must be trained to perform not only as an individual, but also as a member of a team.

1. True
2. False

1-38. The procedures for training new personnel must always be kept the same.

1. True
2. False

1-39. "If in doubt, ask questions!" is a good rule for the trainee.

1. True
2. False

1-40. In addition to being thoroughly familiar with the subject matter you are teaching, what must you also do?

1. Develop the student's pride in his work and in the Navy
2. Show personal mannerisms
3. Use training devices
4. Accomplish all of the above

1-41. New personnel are expected to learn military customs and courtesies, naval discipline, obligations, and responsibilities of citizenship during their

1. indoctrination
2. military training
3. operational training
4. professional training

1-42. Indoctrination in such matters as military customs and courtesies should be confined to training new recruits.

1. True
2. False

1-43. What publication contains the procedures for ordering self-study training courses for active and reserve personnel.

1. Bibliography for Advancement Examination Study, NAVEDTRA 10052 (revised)
2. Manual for Navy Manpower and Personnel Classification and Standards, NAVPERS 18068 (revised)
3. List of Training Manuals and Correspondence Courses, NAVEDTRA 10061, (revised)
4. Personnel Qualification Standard

1-44. In which of the following publications will you find a brief description of correspondence courses available.

1. Bibliography of Advancement, NAVEDTRA 10052
2. Manual of Navy Manpower and Personnel Classifications, NAVPERS 18068
3. List of Training Manuals and Correspondence Courses, NAVEDTRA 10061
4. List of Enlisted Training and Advancement Courses, NAVEDTRA 12345

1-45. Which of the following instructions or publications establishes mandatory requirements for advancement?

1. BUPERSINST 1300.12A
2. BUPERINST 1430.16A
3. NAVEDTRA 10052
4. NAVEDTRA 10061

1-46. Before recommending that a striker be permitted to take an examination for advancement, you should determine that the striker

1. is fully qualified in all respects
2. has fulfilled the minimum service requirements only
3. will complete all qualifications before the examination date
4. will complete all qualifications before the examination date and has a record of faithful service

1-47. The only purpose of the enlisted performance evaluation system is to provide a means for each individual to determine his achievements in the training program.

1. True
2. False

1-48. To make the performance factor in the final multiple for advancement effective, evaluations must differentiate between the performance of each individual.

1. True
2. False

1-49. Evaluations should contain which of the following information?

1. Outstanding performance
2. An individuals shortcoming
3. Complete frankness
4. All of the above

1-50. How often are servicewide examinations for advancement in rating given for paygrade E-4?

1. Annually
2. Semiannually
3. Quarterly
4. Monthly

1-51. Under whose authority was the Apprenticeship Program for Electrical Repairers started?

1. Chief of Naval Operations
2. Secretary of the Navy
3. Secretary of Labor
4. Both 2 and 3 above

1-52. What is the ultimate objective of the National Apprenticeship Standards of the United States Navy?

1. To provide general policy and guidance to commanding officers
2. To document the needs of private industry
3. To provide an adequate training program
4. To provide registered certification of training and achieve equal recognition for Navy and civilian personnel

1-53. The acceptance of skilled Navy personnel by private industry has which of the following effects?

1. Enhancement of employment opportunities for Navy veterans
2. Motivation of Navy personnel to advance while on active duty
3. Provision of a source of registered skilled personnel to meet national manpower requirements
4. All of the above

Learning Objective: Determine some of the purposes of the training records systems and the functions of the long-range, quarterly, and weekly training schedules.

1-54. Training records are kept to show what has been accomplished and what training remains to be accomplished.

1. True
2. False

1-55. As a work center supervisor, you will help maintain the records for the division drill schedule, prepare the bibliography for advancement, and supervise the preparation of the group record of practical factors.

1. True
2. False

1-56. How long should records covering the monthly training plan be kept?

1. 1 year
2. 2 years
3. 3 months
4. 6 months

1-57. All continuous records may be destroyed when information they contain has been transferred to a replacement record.

1. True
2. False

1-58. The Quarterly Training Plan contains which of the following information?

1. One sheet of the long-range plan
2. Latest information on deployment
3. Detailed training intentions for a given quarter
4. All of the above

1-59. What is the highest degree of classified information that can be put in the quarterly and monthly training plan?

1. For Official Use Only
2. Confidential
3. Secret
4. Top Secret

1-60. Which of the following OPNAV Forms are used as the Division Training Schedule?

1. OPNAV Form 1500/30
2. OPNAV Form 1500/32
3. OPNAV From 1600/40
4. OPNAV Form 1600/42

1-61. Each divisional training schedule will cover a maximum time period of

1. 12 months
2. 18 months
3. 24 months
4. 36 months

1-62. If there are several ratings or groups in a division and they do not conduct drills or instruction periods together, they may all use the same Division Training Schedule.

1. True
2. False

1-63. When each person completes a PQS watch station qualification on the PQS Progress Chart, an entry should be made in the

1. division officer's notebook
2. Record of Qualifications at Watch/Battle Stations
3. Division Training Schedule
4. Person's service record

1-64. The group Record of Practical Factors (OPNAV Form 1500-31) is used to keep a record of divisional training in

1. formal schools
2. division drill and instructions
3. practical factors
4. PARs

1-65. What is done with a persons PARs when he is transferred?

1. Erased and given to his relief
2. Discarded
3. Placed in his service jacket
4. Kept on file for 2 years

1-66. What is the OPNAVINST that pertains to the PQS?

1. 3500.16A
2. 3500.34B
3. 3636.17C
4. 36.36.17F

1-67. Which of the following publications provides information on the PQS concept and describes its implementation?

1. 10858-F
2. 10052-B
3. 43100-1
4. 10061-D

Learning Objective: Recognize the purpose and types of inspections held in the engineering department, and describe the methods and procedures for conducting each.

● Information for questions 1-68 and 1-69. An inspection party from destroyer A boards destroyer B and proceeds to carry out a competitive material inspection.

1-68. Which of the following officers will most probably determine the type of inspection to be held aboard destroyer B?

1. Fleet commander
2. Type commander
3. Commanding officer of destroyer B only
4. Commanding officer of destroyer B and the commanding officer of destroyer A

1-69. The inspection party was most probably selected by the

1. CNO
2. type commander
3. division commander
4. commanding officer of destroyer A

1-70. The administrative inspection of a ships engineering department is concerned with the ship's readiness to carry out its basic mission.

1. True
2. False

1-71. The appearance of the engineering personnel is evaluated for grading purposes during administrative inspections.

1. True
2. False

1-72. During the general administrative inspection, which of the following factors has a direct bearing on the ship's engineering department?

1. Acquaintance of engineering personnel with the ship's administrative procedures
2. Proper maintenance of operating logs
3. Indoctrination procedures for new personnel
4. All of the above

1-73. An administrative inspection of a ship's - engineering department is principally cons cerned with which of the following aspect of the department's administration?

1. Paper work
2. Administration of divisional responsibilities
3. Assignment of personnel to administrative duties
4. Training facilities

1-74. Who normally provides checkoff lists for administrative inspections of ships?

1. Type commander
2. Division commander
3. Captain of the ship that will conduct the inspection
4. Captain of the ship that will be inspected

1-75. An administrative inspection is being conducted in the engineering department. Which of the following bills should be inspected by the assistant inspector for adequacy, completeness, and correctness?

1. Fueling bill
2. Engineering Casualty Bill
3. Watch, Quarter, and Station Bills
4. All of the above

Assignment 2

Inspections and Maintenance (continued)

Textbook Assignment: Pages 2-2 through 2-15

Learning Objective: Recognize the purpose and types of inspections held in the engineering department, and describe the methods and procedures for conducting each.

● Information for questions 2-1 and 2-2. An inspection party from destroyer A boards destroyer B and proceeds to carry out a competitive material inspection.

2-1. The effectiveness of divisional training is one vital area covered during an administrative inspection.

1. True
2. False

2-2. Which of the following items will best prepare a division supervisor for an administrative inspection?

1. Division officer inspection guide
2. Type commander inspection schedule
3. Commanding officer's internal directive
4. Administrative inspection check-off list

2-3. The best way for an inspector to determine whether personnel are familiar with the operating instructions of their department is to question which of the following individuals?

1. Department head concerning the methods of instruction
2. Leading petty officers of the department
3. Newly assigned or nonrated personnel in the department
4. Personnel at random

2-4. Which of the following requirements must a division supervisor meet when assigning personnel to stations and watches?

1. Sufficient personnel onboard to get the ship underway
2. Sufficient personnel are under instruction to relieve other personnel
3. Only senior personnel are assigned to vital watch stations
4. Only personnel who have recently qualified for watches are assigned to vital stations

2-5. How does an inspector determine the methods employed in the engineering department to locate stowed items?

1. By examining the various supply records and forms
2. By inspecting the stowage bins and boxes
3. By asking a senior petty officer how he would locate an item
4. By questioning a departmental officer on the methods employed

2-6. Which of the following documents is NOT checked during an administrative inspection?

1. PMS schedules
2. Training records
3. Fueling bills
4. COSAL

2-7. What type of inspection is mainly concerned with a ships ability to carry out its wartime missions?

1. Administrative inspection of the ship as a whole
2. Administrative inspection of the ship's departments
3. Operational readiness inspection
4. Material inspection

2-8. Which of the following areas does an operational readiness inspection look at closely?

1. Antiaircraft, surface, and gunnery
2. Damage control
3. Engineering casualty control
4. All of the above

2-9. Which of the following types of inspections include battle problems?

1. Material inspections and operational readiness inspections
2. Operational readiness inspections only
3. Material inspections only
4. All formal inspections

2-10. The operational readiness observing party differs from the administrative inspecting party in that the operational readiness observing party usually contains

1. fewer warrant officers
2. more third class petty officers
3. fewer commissioned officers
4. more leading petty officers

2-11. How is a ships performance during its operational readiness inspection measured?

1. By the standard of professional ability attained by the crew
2. By the ship's ability to perform its wartime functions adequately
3. By the completeness, adequacy, and implementation of its Battle Bill
4. By each of the above

2-12. What is the primary purpose of a shipboard battle problem?

1. Provides an opportunity for all hands who wish to participate, to do so
2. Allows all machinery to be tested
3. Provides a medium for testing and evaluating the ability of all divisions to function together as a team
4. Allows senior personnel a chance to pass along their knowledge

2-13. The value of a battle problem to a ship's company is directly proportional to which of the following factors?

1. Amount of preparation time allowed the ships company before zero problem time
2. Amount of realism provided in the problem
3. Skill of the observing party evaluating operational procedures
4. Number of trained observers conducting the problem

2-14. What specific element increases the value of a battle problem to a ships company?

1. Surprise
2. Dress rehearsal
3. Advance notice
4. Suspense

2-15. Which of the following types of information should be supplied to a ship before a battle problem begins?

1. The time of "darken ship" inspection
2. The time of a simulated casualty to the power supply
3. The end of problem time
4. The time of JV telephone circuit casualty

2-16. When practicable, during a battle problem, pertinent information should be given verbally by observers to the ships crew.

1. True
2. False

2-17. When may an observer coach ships personnel during a battle problem?

1. When questioned by personnel concerning imposed casualties
2. When imposed casualties are undiscovered by personnel
3. When it is inconvenient to simulate casualties
4. When the corrective action taken by personnel is inappropriate

2-18. During a battle problem, a valve must be closed in order to simulate a casualty to a main engine. Which of the following personnel should actually close the valve?

1. The assistant inspector
2. A member of the observing party
3. A member of the ship's engineering force
4. Either a member of the ship's engineering force or a member of the observing party

2-19. During a battle problem, an observer has requested that the feedwater to the boilers be shut off to simulate a boiler casualty. What should the engineer officer of the watch do?

1. Direct the engine room personnel to do whatever the observer requests
2. Make sure the supply of lubricating oil to the main engines is stopped at the same time
3. Deny the request
4. Allow only the observer to handle the shutoff valve

2-20. Which of the following personnel are responsible for setting up provisions for emergency action in case of a real casualty during a battle problem?

1. Type commander
2. Ships company and the observing party
3. Ships company only
4. Observing party only

2-21. Who uses the engineering telephone circuits during the battle problem?

1. The observing party, to announce start and end of the problem
2. The observing party, in cases of actual casualty
3. The ships personnel, in case of actual casualty only
4. The ships engineering personnel, to cope with the battle problem assigned to the ship

2-22. In a shipboard battle problem, observers should use equal effort to note excellence as well as weakness.

1. True
2. False

2-23. The analysis of a battle problem is divided into what two steps?

1. Critique and observers reports
2. Captain's report and observers' reports
3. Critique and ships company report
4. Observers' and ships company reports

2-24. Which of the following personnel attend the critique that is held aboard ship after a battle problem?

1. Commanding officer, department heads, chief observer, and senior observer
2. All ship's officers, chief observer, and senior observers
3. All ship's officers, some chiefs and first class petty officers, chief observer, and senior observers
4. All ship's officers, some chiefs and first class petty officers, and chief observer

2-25. Who sets down the format of the observers' reports?

1. The senior observer for each department
2. The chief observer
3. The type commander
4. The fleet commander

2-26. After an operational readiness inspection, one purpose of supplying the inspected ship with copies of the inspector's report is to provide the inspected ship with what type of documentation?

1. Checkoff list for correcting defects
2. Statement of probable action by the type commander
3. Schedule for future overhaul periods
4. Statement of condition of material in comparison with other ships in the division

2-27. When evaluating the performance of an engineering department during a battle problem, an observer checks the extent to which the engineering department carries out which of the following tasks?

1. Exercise engineering casualty control measures
2. Utilizes damage control features built into the ship
3. Maintains maximum mobility and manueverability of the ship
4. Each of the above

2-28. The specific purpose of the material inspection is to determine which of the following condition(s)?

1. Ship's machinery is kept clean
2. Cleanliness of a ship's compartments meets acceptable standards
3. Correct procedures are being used in the maintenance of machinery and equipment
4. Military bearing and appearance of a ship's personnel have improved materially since the last inspection

2-29. Which of the following types of inspections is similar to the Board of Inspection and Survey inspection?

1. The shipwide administrative inspection
2. The departmental administrative inspection
3. The material inspection
4. The operational readiness inspection

2-30. Unless they have a direct bearing on the material condition, administrative methods and cleanliness should NOT be considered as part of a material inspection?

1. True
2. False

2-31. A list of the units to be opened is furnished to the ship for material inspection by which of the following personnel/offices?

1. Type commander
2. Board of Inspection and Survey
3. Chief inspector
4. Individual inspectors

2-32. All material deficiencies found during an inspection, but NOT included on the Work List, are noted as discrepancies by the chief inspector.

1. True
2. False

2-33. The information on the condition sheets provided to the inspection party describes what condition?

1. The machinery to be opened
2. The machinery to be tested
3. All parts of the ship, and all machinery and equipment on board
4. Machinery to be operated

2-34. The preliminary copies of the condition sheets to be used for a material inspection are filled in by which of the following activities or personnel?

1. Type commander
2. Division commander
3. Ship that conducts the inspection
4. Ship to be inspected

2-35. Which of the following items should be entered on a condition sheet?

1. Machinery to be opened for inspection
2. Equipment to be operated
3. Material condition of an inoperative safety device
4. Each of the above

2-36. Condition sheets describe the condition of the ship's hull, machinery, and equipment. Condition sheets are filled in by the inspected ship's company and used by the inspection party as a checkoff list and inspection record during the inspection. After the inspection, condition sheets are used in preparing the final inspection report on the condition of the ship.

1. True
2. False

2-37. What is the importance of chapter 090 of the Naval Ships' Technical Manual?

1. It is a guide for use when opening particular machinery units
2. It is a comprehensive material inspection guide
3. It is a guide for preparing work lists
4. It is a guide for preparing condition sheets

2-38. Who furnishes the condition sheets used in material inspection?

1. Inspecting party
2. Inspecting ship
3. Division commander
4. Type commander

2-39. Which of the following statements describes the manner in which a material inspection should proceed?

1. All equipment of the same type should be inspected simultaneously
2. A predetermined inspection schedule should be followed
3. Inspection of each space should be completed before the next is begun
4. Inspections of all units should be made with the knowledge and assistance of ship's personnel

2-40. Which of the following is a main inspection item for a material inspection of engineering spaces?

1. Procedures used for the replacement of repair parts
2. Installation and maintenance of required fire-fighting equipment in the engineering spaces in accordance with up-to-date procedures
3. Maintenance of equipment custody cards
4. Knowledge by responsible engineering personnel of current instructions regarding routine testing and inspections

2-41. After a material inspection, one purpose of supplying the inspected ship with copies of the inspector's report is to provide the ship with what documentation?

1. Checkoff list for correcting defects
2. Statement of probable action by the type commander
3. Schedule for future overhaul periods
4. Statements of condition of material in comparison with other ships in the division

2-42. Who evaluates the results of a material inspection on the basis of reports submitted to the inspector of each inspection group?

1. CNO
2. Type commander
3. Ship's commanding officer
4. Chief inspector

2-43. The main difference between a material inspection group and the Board of Inspection and Survey is that the Board

1. is interested mainly in operational readiness
2. is not from Forces Afloat, but is especially appointed
3. contains at least 10 officers
4. is interested mainly in administrative efficiency

2-44. Following a shipboard material inspection, which of the following items will be included in the report submitted by the Board of Inspection and Survey?

1. The general condition of the ship
2. The suitability of the ship for further service
3. A list of proposed repairs, alterations, and design changes
4. Each of the above

2-45. After conducting trials and inspections of a new or converted ship prior to final acceptance for naval service, the Board of Inspection and Survey will include in its report all of the following information EXCEPT the

1. recommended changes in design
2. existing defects and deficiencies in material and performance
3. explanation of how speed and shaft horsepower are determined
4. opinion as to who is responsible for correcting reported defects

2-46. To whom does the Board of Inspection and Survey submit recommendations for the acceptance or rejection of a new ship?

1. Bureau of Ships
2. Prospective fleet commander
3. Chief of Naval Operations
4. Secretary of the Navy

2-47. Which of the following tests are included in the acceptance trial tests?

1. Full power runs and boiler overload tests
2. Quick-reversal and backing tests
3. Steering and anchor engine tests
4. All of the above

2-48. Who initiates the inspection of a ship by the Board of Inspection and Survey?

1. The type commander
2. The commanding officer
3. BUSHIPS
4. The Chief of Naval Operations

Learning Objective: Indicate familiarity with the procedure for conducting routine ship trials.

2-49. Which of the following trials are considered routine ship's trials?

1. Laying up, final acceptance, and recommissioning
2. Tactical, standardization, and post repair
3. Economy, post repair, and full power
4. Preliminary acceptance, economy, and builder's

2-50. Which of the following ships should be required to have a post repair trial?

1. An MSO deploying to the Mediterranean
2. A DE finishing extensive repairs to its hull
3. An AO switching home ports from Norfolk to San Diego
4. A CVS completing a routine naval shipyard overhaul period

2-51. The specific nature of a post repair trial is determined by which of the following personnel?

1. Type commander
2. Commanding officer of the ship
3. Shipyard commander
4. Both 2 and 3 above

2-52. Before a competitive trial is conducted, how much time is a ship normally allowed to test and adjust the machinery overhauled by naval shipyard personnel?

1. 1 week
2. 2 weeks
3. 20 days
4. 1 month

2-53. Which of the following ship's trials is classified as a competitive trial?

1. Standardization
2. Economy
3. Tactical
4. Recommissioning

2-54. Before a full power trial, the ship's engineer officer must make a report on the condition of the engineering plant to whom?

1. Board of Inspection and Survey
2. Chief inspector
3. Engineering inspector
4. Commanding officer

2-55. What kind of trouble can be expected if a full power trial is held in shallow water?

1. Excessive speed
2. Multiple pump failures
3. Overloading of the propulsion plant
4. Foaming of lube oil in reduction gears

2-56. A full power trial planned for 3 hours duration has to be interrupted at the end of 2 hours. What action should be taken?

1. The remaining hour of the full power trial should be completed at the first opportunity
2. 2 more hours of full power trial should be conducted at the first opportunity
3. The trial should be regarded as unsatisfactory and another trial of 3 hours duration should be held at the first opportunity
4. The trial should be regarded as unsatisfactory and a special report should be made to the Board of Inspection and Survey

2-57. When should the displacement corresponding to the ship's draft be recorded during a trial run?

1. At the start and end of the trial only
2. At the middle of the trial only
3. At the start, middle, and end of the trial
4. Every hour of the trial

2-58. Who determines the full-power speed requirements for a ship that is running a full-power trial?

1. The chief observer
2. The type commander
3. BUSHIPS
4. The Chief of Naval Operations

2-59. Before the official full power trial period starts, the ship is normally operated at full power long enough to permit all readings to become constant.

1. True
2. False

2-60. An economy trial is normally conducted over a period of

1. 6 hr
2. 5 hr
3. 3 hr
4. 4 hr

2-61. When a ship fails a performance trial, the type commander may specify a retrial which he deems appropriate to demonstrate satisfactory engineering readiness.

1. True
2. False

2-62. Which of the following actions is NOT a duty of the assistant chief observer?

1. Taking counter readings
2. Supervising the engineroom observers
3. Checking tank soundings
4. Checking fuel oil meter readings

2-63. Which of the following personnel makes out the economy trial report?

1. Commanding officer
2. Chief observer
3. Assistant chief observer
4. The assistant observers

2-64. What information should be furnished in writing to the chief observer prior to the start of a full power trial?

1. Date of last undocking
2. Dates of last testing of all machinery safety devices
3. Authorized and actual settings of all main machinery safety settings
4. All of the above

2-65. When a minimum draft has NOT been specified by trial requirements, the liquid loading should NOT be less than what percentage of the full load capacity?

1. 25%
2. 50%
3. 75%
4. 90%

2-66. When should the chief observer determine the ship's draft and trim for a trial?

1. Before and after the trial
2. At the middle of the trial
3. At the start, middle, and end of the trial
4. Every hour of the trial

2-67. How often are readings taken and recorded during an economy trial?

1. Every half hour
2. Every hour
3. At the start and end of the trial
4. At the start, middle, and end of the trial

2-68. A ship undergoing a 4-hour full power trial is equipped with a torsionmeter for measuring shaft horsepower. To determine the power being developed, how many observations should be taken?

1. At least one during the trial
2. At least two during the trial
3. At least one each hour
4. At least two each hour

2-69. Which of the following actions is NOT a responsibility of engineering department personnel during an engineering trial?

1. To provide observers with a written statement of the date of the ship's last undocking
2. To ensure that clocks are synchronized in all engineering spaces and on the bridge
3. To provide the usual housekeeping and auxiliary loads
4. To check the setting of machinery safety devices

Learning Objective: Recognize safe and unsafe working conditions pertaining to hearing conservation.

2-70. Exposure to continued or intermittent sounds can cause loss of hearing.

1. True
2. False

2-71. Loss of hearing sensitivity generally occurs in which of the following ranges?

1. 6,000 to 10,000 Hz
2. 4,000 to 6,000 Hz
3. 3,000 to 4,000 Hz
4. 500 to 3,000 Hz

2-72. What is the purpose of the hearing conservation program?

1. To identify noise sources
2. To reduce exposure of personnel to potentially hazardous noises
3. To test the hearing of noise-exposed personnel
4. To provide hearing-conservation devices

2-73. All personnel who are exposed to potentially hazardous noise may wear hearing protection devices at their own discretion.

1. True
2. False

2-74. Which of the following organizations is responsible to provide technical assistance and engineering guidance to commands on noise abatement?

1. Type commander
2. Chief of Naval Material
3. Chief of Naval Education and Training
4. Chief of Naval Operations

2-75. Which of the following organizations assist the Chief of Naval Education and Training (CNET) and engineering control guidance information in the curricula of all appropriate training courses?

1. CHBUMED
2. CHNAVMAT
3. Both 1 and 2 above
4. NAVINSGEN

Assignment 3

Inspections and Maintenance (continued) and Engineering Casualty Control

Textbook Assignment: Pages 2-16 through 2-21 and pages 3-1 through 3-24

Learning Objective: Recognize your responsibilities concerning hearing conservation.

3-1. Which of the following dBA ratings does NOT require the posting of potentially hazardous warning labels?

1. 50 dBA
2. 100 dBA
3. 150 dBA
4. 200 dBA

3-2. What instruction provides a listing of activities where industrial hygiene assistance may be obtained?

1. SUBPACINST 6200.2
2. OPNAVINST 6260.2
3. ROMACINST 6320.1
4. DESRONINST 6460.4

3-3. Which of the following actions is the engineering officer required to perform?

1. Have newly reporting personnel receive a hearing test
2. Advise the medical department who is working in high noise areas
3. Arrange for noise survey to be taken
4. Each of the above

3-4. What is the maximum time allowable between noise level surveys taken aboard ship?

1. 6 months
2. Yearly
3. Every 2 years
4. After each major yard period

3-5. Who is responsible for issuing aural protective devices onboard ship?

1. Duty corpsman
2. Main propulsion assistant
3. Engineer officer
4. Division officer

3-6. Where are requirement conflicts between the Quality Assurance Manual 9090.1 and COMNAVSURFLANT sent?

1. CNO
2. Type commander
3. Bureau of ships
4. COMNAVSURFLANT

3-7. Which of the following responsibilities would be yours as a work center supervisor?

1. Posting safety signs in your work spaces
2. Training and counseling your personnel on the effects of noise pollution
3. Insuring they have hearing protection
4. Each of the above

3-8. How often should your ship's steering gear be inspected?

1. During major overhaul
2. Every 2 years
3. Before major deployments
4. Every 4 years

3-9. An IMA that conducted a steering gear inspection is required to keep its copy on file for at least how long?

1. 1 yr
2. 2 yr
3. 3 yr
4. 4 yr

3-10. How are PMS schedules categorized?

1. Cycle, quarterly, and monthly
2. Quarterly, monthly, and weekly
3. Cycle, monthly, and weekly
4. Cycle, quarterly, and weekly

3-11. Who supervises cycle scheduling of PMS for the engineering department?

1. Engineer officer
2. 3-M coordinator
3. Engineering 3-M assistant
4. Applicable work center supervisor

3-12. Completed quarterly PMS Schedules are required to be kept on file for what period of time?

1. 9 months
2. 12 months
3. 15 months
4. 18 months

3-13. By whom and how frequently is the Quarterly PMS Schedule updated?

1. Work center supervisor every day
2. Work center supervisor every week
3. Division officer every month
4. Division officer every week

3-14. The Weekly PMS Schedule contains a blank space for the signature of the what official?

1. Engineer officer
2. Division officer
3. 3-M assistant
4. Work center supervisor

3-15. Under which of the following conditions would you use the OPNAV Form 4790/2K?

1. To request transferring a piece of equipment to another work center
2. To request PMS Maintenance Requirement Cards
3. To request a shipyard's assistance
4. To request consumable materials

3-16. What is the purpose of the OPNAV Form 4790/2L?

1. To defer a piece of equipment
2. To document completion of a job order
3. To request work from an IMA
4. To amplify information described on a 4790/2K

3-17. Which of the following forms is an automated work request produced by an IMA with computer capabilities?

1. OPNAV Form 4790/2K
2. OPNAV Form 4790/2L
3. OPNAV Form 4790/2Q
4. OPNAV Form 1348

3-18. To check on the availability of materials before starting work on a maintenance job is an important part of careful planning because failure to do so may result in which of the following conditions?

1. Wasted effort
2. Unsafe working condition
3. Useless equipment
4. Each of the above

3-19. The amount of information required to be given to the personnel doing a particular repair job will depend largely on which of the following considerations?

1. The safety precautions you expect them to ignore
2. The man-hours estimated to complete the job
3. The experience of the personnel assigned to the job
4. The degree of care with which you expect to inspect the job upon completion

3-20. A careful inspection should be conducted after a job has been completed to ensure that the work was properly performed and that necessary records or reports have been prepared.

1. True
2. False

3-21. When estimating the amount of time required to accomplish a repair, what factor(s) should you take into consideration?

1. The personnel who can best do the job
2. The number of personnel required for the work
3. The availability of the repair materials
4. Each of the above

3-22. The accuracy of job estimates that you must submit to your division officer is important because such estimates may affect the operational schedule of the ship.

1. True
2. False

3-23. When more than one shop is required to complete an electric motor repair, each shop should make a separate time estimate of the job.

1. True
2. False

3-24. In addition to the actual time required for the work itself, what other factors must be considered in arriving at a final estimate for a particular job?

1. Drills
2. Inspections
3. Working parties
4. All of the above

3-25. Dividing a total job into sub-jobs and then determining the time and number of personnel required for each sub-job is a waste of labor and time for the purpose of arriving at accurate estimates.

1. True
2. False

3-26. Which of the following estimates is often the most difficult for a supervisor to make in arriving at a job completion time?

1. Tools required
2. Materials required
3. Personnel required
4. Time and labor required

3-27. You are responsible for submitting an estimate of the materials required to complete a job. If the job is one your shop handles regularly, which factor is a basis for making an accurate estimate?

1. Records of the jobs kept by the shop
2. In-service conditions to be fulfilled
3. Condition of tools and equipment
4. Availability of the materials

3-28. Which of the following officials does NOT sign the PMS Feedback Report?

1. Executive officer
2. Engineer officer
3. Division officer
4. 3-M coordinator

Learning Objective: Point out some fundamentals of engineering casualty control.

3-29. What is the primary objective of engineering casualty control?

1. To minimize personnel casualties
2. To operate engineering equipment at maximum economy
3. To maintain the efficiency of the engineering equipment
4. To minimize secondary damage to the engineering equipment

3-30. Which of the following actions is the most effective phase of casualty control?

1. Prevention
2. Training
3. Restoration
4. Communications

3-31. Which of the following are the causes for most engineering plant casualties?

1. Misadjustments, improper lubrication and corrosion
2. Lack of knowledge or correct procedures on the part of watch station personnel
3. Lack of effective communications
4. All of the above

3-32. Which of the following is/are the primary emphasis in casualty control training?

1. Speed
2. Decreased plant disablements
3. Safety
4. Both 2 and 3 above

3-33. What should be the primary source of information when you are making the drill scenario cards for the ECCET team members?

1. PMS cards
2. EOCC
3. Past experience
4. Manufacture technical manuals

3-34. Who must approve electrical casualty control drills?

1. Engineer officer of the watch
2. Electrical officer
3. Engineer officer
4. Commanding officer

3-35. Which type of drill should be given first priority because it represents the greatest danger?

1. Electrical generator drill
2. Main engine room casualty
3. Loss of communication drill
4. Boiler casualty

3-36. ECCET team members should NEVER assist the watch team in restoring the plant to proper operation.

1. True
2. False

3-37. Which of the following examples is a reason for an unsatisfactory grade on a casualty control drill?

1. Loss of plant control by space supervisor or EOOW
2. Safety violations
3. Lack of knowledge of proper procedures
4. All of the above

Learning Objective: Recognize the different phases of EOSS.

3-38. For which of the following reasons was EOSS designed?

1. To increase operational efficiency
2. To provide better plant control
3. To reduce operational casualties
4. All of the above

3-39. What is the final step in the development phase of EOSS?

1. Work-study techniques
2. Analytic phase
3. Validation on-board ship
4. Preparing configuration diagrams

3-40. Which of the following information is contained in the operational portion of EOSS?

1. Scheduling plant evolutions
2. Controlling plant evolutions
3. Directing plant evolutions
4. Each of the above

3-41. Which of the following personnel or components does stage 1 of the EOP deal with?

1. Component operators
2. Space superviser
3. Total plant supervisor
4. Equipment only

3-42. In what stage(s) of EOP will you find a diagram showing generator combinations for the various operating conditions.

1. Stages 1 and 2
2. Stages 1 and 3
3. Stages 2 and 3
4. Stage 3 only

3-43. The operational use of EOP documentation is of primary importance at all levels in controlling, supervising, and operating the evolutional functions of the engineering plant.

1. True
2. False

3-44. EOCC manuals are available to personnel in their own machinery spaces so that they can be used as a means of self-indoctrination for newly assigned personnel.

1. True
2. False

3-45. Primary training in EOCC procedures concentrates on which of the following casualties?

1. Battle problems
2. Fire room casualties only
3. Single source casualties
4. Multiple casualties

3-46. What is the most important factor in efficient casualty control procedures?

1. Accuracy of corrective action
2. Status of personnel training
3. Speed in cross-connecting an intact system with a partially damaged system
4. Speed in restoring damaged units

3-47. Continuous operation of equipment under casualty conditions is a responsibility of which of the following ships officers?

1. Operations officer
2. Commanding officer
3. Engineering officer
4. Officer of the watch

3-48. Who does the EOOW report to for changes in speed and direction of rotation of the main propulsion shafts and for requirements of standby power and other engineering services anticipated or ordered?

1. Operations officer
2. Officer of the deck
3. Engineer officer
4. Commanding officer

3-49. What is the primary means of communication between the engineer officer and the various watch teams during casualty control procedures?

1. Sound-powered telephones
2. A general announcing system
3. Messengers
4. Ships service telephones

3-50. It is not the responsibility of the telephone talker to decipher, translate, or rephrase improperly transmitted orders.

1. True
2. False

3-51. Assume that valves X, Y, and Z, must be opened to cross-connect main feed portside. Which of the following commands will be most effective in accomplishing the cross-connection?

1. "Port side, open all main and auxiliary feed valves"
2. "Cross-connect main feed port side"
3. "Port side, open valves X, Y, and Z"
4. "Open main and auxiliary feed valves X, Y, and Z, portside"

3-52. Who is responsible for marking the casualty control board located in the after engine room?

1. Messenger from Repair 5
2. Engineer officer
3. 2JV talker
4. Duty MMC

3-53. In which of the following NAVPERS manuals will you find information concerning occupational standards?

1. 17065-B
2. 17805-D
3. 18068-D
4. 19061-C

3-54. A damage control repair party must be able to perform which of the following functions?

1. Make repairs to electrical and sound-powered telephone circuits
2. Detect, identify, and measure radiological contamination
3. Sample, or identify biological or chemical agents
4. All of the above

3-55. Personnel assigned to Repair 5 must be able to maintain, repair, or isolate damage to main propulsion machinery and boilers.

1. True
2. False

3-56. Where would a graphic display board showing damage and action taken to correct disrupted or a damaged system be located?

1. Electrical shop
2. Combat
3. Repair lockers
4. Log room

Learning Objective: Recognize some fire-room, engine-room and propulsion plant casualties, and procedures for handling them.

3-57. What is the most important single factor in efficient control of a fire-room casualty affecting engine-room operation?

1. Flow of information between affected spaces
2. Speed of corrective action
3. Safety of personnel
4. Speed in cross-connecting standby units

3-58. Which of the following actions should you take when the fire room reports a boiler high water casualty during split plant operation?

1. Trip the ships service generator circuit breaker
2. Close the bus-ties
3. Both 1 and 2 above
4. Trip the ships service turbogenerator

3-59. Which of the following actions should you take when the fire room reports a boiler low water casualty?

1. Trip generator circuit breaker
2. Maintain 60 cycle
3. Trip non-vital circuits
4. Both 2 and 3 above

3-60. Assume that you are in charge of a fire-room team. Your personnel report to you that the burners are sputtering and the fuel-oil service pump is suddenly racing. Which of the following is the probable cause of the trouble?

1. The pump is airbound
2. The fuel-oil pump has lost suction
3. The fuel-oil suction line is clogged
4. All of the above

3-61. Which of the following procedures should the fire-room watch carry out if loss of fuel oil suction occurs?

1. Secure the burners and blowers and start the standby service pump with suction on the stand-by service tank
2. Secure the burners and blowers and start the stand-by service pump with suction on the regular service tank
3. Secure the burners, keep the blowers running, and start the stand-by service pump with suction on the stand-by service tank
4. Secure the burners, close all registers, keep the blowers running, and start the stand-by service pump with suction on the stand-by service tank

3-62. What is the first corrective action you should take if one of a ship's two propulsion shafts begins to vibrate excessively?

1. Investigate the spring bearings
2. Slow the affected shaft
3. Stop and secure the affected shaft
4. Slow both shafts

3-63. While you are standing the engine room watch, one of the turbines begins to vibrate. What should you do?

1. Reduce the engine speed and the superheat temperature
2. Increase the engine speed and reduce the superheat temperature
3. Stop the engine and notify the officer of the watch
4. Stop the engine and investigate to determine the cause

3-64. What is the general procedure when very low lubricating oil pressure occurs?

1. Line-up stand-by pump in case pressure drops to zero psi
2. Boost steam pressure to pump
3. Both 1 and 2 above
4. Stop the affected shaft and simultaneously endeavor to regain lubricating oil pressure

3-65. Assume that the shaft affected by low lubricating oil pressure is rotating at three-quarter full-power speed. To stop the shaft, if steam is available, you should

1. close ahead throttle
2. open astern throttle
3. engage jacking hear
4. perform actions 1, 2, and 3 above

3-66. What is the determining factor on how long a generator may safely be operated in an over loaded condition?

1. Operator vigilance
2. Generator winding temperature
3. Electrical officer discretion
4. Generator size

3-67. Which of the following extinguishing agents is used for electrical fires?

1. CO_2
2. Chemical foam
3. Mechanical foam
4. Water fog

3-68. If the lube oil pressure to a ship's service turbogenerator is lost while operating split plant, the usual steps to be taken in securing the affected generator include which of the following actions?

1. Tripping the generator circuit breaker
2. Maintaining oil pressure by means of a hand-operated lube oil pump
3. Closing bus-ties and the generator turbine throttle valve
4. All of the above

3-69. Main propulsion generators may NOT be cut out of the circuit when their engine speed is greater than 350 rpm.

1. True
2. False

3-70. Which of the following is/are the first step(s) taken to shift control from the pilothouse control console to the engine room station?

1. Turn the excitation switch in pilothouse of off
2. Turn the excitation switch in engine room to ON
3. Both 1 and 2 above
4. Place both control stations in OFF position

3-71. When tagging out a damaged switchboard, where should you place the tag out tags?

1. On the damaged switch board
2. At the breakers for incoming power
3. At the source of power
4. In the general vicinity of the switchboard

3-72. Which of the following is/are the important feature(s) of the casualty power system?

1. To allow temporary repairs
2. To allow preservation of watertight integrity
3. To provide the ability to test run motors
4. All of the above

3-73. What is the standard letter and number designation for a casualty power cable?

1. THOF - 40
2. THOF - 42
3. TSGA - 40
4. TSGA - 42

3-74. The normal current carrying capacity in amperes of casualty power cable is
______(a)______ and its casualty
90 amp, 93 amp
rating is ______(b)______.
150 amp, 200 amp

1. (a) 90 amp (b) 200 amp
2. (a) 90 amp (b) 150 amp
3. (a) 93 amp (b) 200 amp
4. (a) 93 amp (b) 150 amp

3-75. What type of circuit breaker is used on the back of ship's service switchboards to provide power to the casualty power terminals?

1. ACB
2. NQB
3. AQB
4. NCB

Assignment 4

Voltage and Frequency Regulation

Textbook Assignment: Pages 4-1 through 4-39

Learning Objective: Recognize some of the characteristics of type I, type II, and type III a.c. power systems.

4-1. Which electrical characteristic is expressed as ±16 percent in table 4-1 of the textbook?

1. Average of the three line-to-line voltages
2. Voltage transient limits
3. Total harmonic distortion
4. Frequency transient recovery time

4-2. What are the respective maximum and minimum line voltage unbalance's for type II 440 volt a.c. power systems?

1. 451.7 V - 428.1 V
2. 453.2 V - 426.8 V
3. 456.5 V - 430.2 V
4. 458.2 V - 438.3 V

4-3. What is the total harmonic distortion for a 440-volt type III a.c. power system?

1. 9.4 V
2. 10.6 V
3. 13.2 V
4. 15.1 V

4-4. The main difference between type I and type II power systems is that type II requires

1. better voltage control at the load
2. isolation of the load from the power system
3. less frequency regulation
4. generator voltage control rather than load voltage control

4-5. Motor generator sets or static frequency changers are normally used to provide type III power requirements.

1. True
2. False

Learning Objective: Point out operating principles of the direct acting type voltage regulator and procedures for operating ship's service installations using this type of regulator.

4-6. Spare voltage-sensitive control elements are not installed for voltage regulators used on which of the following equipment?

1. Motor generator sets
2. Ship service switchboard
3. Emergency switchboard
4. Static frequency changers

4-7. Which part of the direct acting rheostatic type voltage regulator exerts a mechanical force directly on a special type of regulating resistance?

1. Interlocking springs
2. Electric solenoid
3. Regulator coil
4. Leaf springs

4-8. The voltage regulator is connected in series with the shunt field of the exciter.

1. True
2. False

4-9. The silver buttons in a Silverstat type voltage regulator are connected to taps on what component(s)?

1. Regulator coil
2. Voltage adjusting rheostat
3. Regulating resistance plates
4. Range-setting resistors

4-10. The range covered by each voltage adjusting rheostat of the regulator can be set so the midposition of the rheostat is in the normal operating position to obtain rated generator voltage. The range is set by adjusting what component(s)?

1. Damping transformer
2. Resistors connected in series with the regulator coil
3. Resistance plate connected in series with the rheostat
4. Resistance plate connected in parallel with the rheostat

4-11. Where is the primary of the damping transformer connected in a regulator that controls a large a.c. generator?

1. Across the output of the exciter
2. In series with the voltage adjusting rheostat
3. In series with the regulator coil
4. Across the output of the crosscurrent compensator

4-12. When switching a direct acting voltage regulator system from manual to automatic control, it is necessary to leave the control switch in the TEST position momentarily to allow the

1. exciter field current to stabilize
2. generator field current to stabilize
3. damping transformer transient current to die down
4. silver buttons to readjust

4-13. How does a direct acting voltage regulator respond to a decrease in generator load?

1. The regulator armature is pulled toward the regulator coil, more silver buttons are pushed together, and the regulating resistance increases
2. The regulator armature is pulled toward the regulator coil, more silver buttons are spread apart, and the regulating resistance increases
3. The regulator armature is pulled away from the regulator coil, more silver buttons are pushed together, and the regulating resistance decreases
4. The regulator armature is pulled away from the regulator coil, more silver buttons are spread apart, and the regulating resistance decreases

4-14. How will the moving arm of a direct acting regulator behave if the damping transformer connections are reversed?

1. It will swing continuously from one end of its travel to the other
2. It will move very sluggishly in response to a generator voltage change
3. It will be pulled toward the regulator coil and remain in that position
4. It will be pulled away from the regulator coil and remain in that position

---

Learning Objective: Identify operating principles of the rotary amplifier (amplidyne) type of voltage regulator and procedures for operating ship's service installations using this type of regulator.

4-15. The voltage regulator transfer switch for two generators, A and B, is in the GEN B position. How are the voltages of the generators controlled?

1. Both generators are controlled by generator B's regulator
2. Only generator B is regulated, since generator A is out of the circuit
3. Generator A is controlled by the standby regulator and generator B is controlled by its own regulator
4. Generator A is controlled by its own regulator, and generator B is controlled by the standby regulator

4-16. The stabilizer functions to prevent hunting in the voltage regulator circuit by producing a voltage that

1. aids any change in amplidyne control field current
2. decreases the inductance of the saturated reactor
3. increases the inductance of the saturated reactor
4. opposes any change in amplidyne control field current

4-17. When the number of saturated reactor coil turns in the voltage adjusting unit is decreased, the inductance of the saturated reactor

1. decreases, and the voltage held by the regulator is lowered
2. increases, and the voltage held by the regulator is lowered
3. decreases, and the voltage held by the regulator is raised
4. increases, and the voltage held by the regulator is raised

4-18. What unit provides the regulator with a signal proportional to the a.c. generator voltage?

1. Pilot alternator
2. Amplidyne unit
3. Potential unit
4. Stabilizer

IN ANSWERING QUESTION 4-19, REFER TO FIGURE 4-6 IN THE TEXTBOOK.

4-19. When the generator voltage is near normal in the automatic control circuit, buck circuit current from F2 to F1 in the amplidyne control field is

1. nearly equal to the boost circuit current
2. maximum to overcome the boost circuit current
3. minimum to enable the boost circuit current to keep the amplidyne control field steady
4. negligible

4-20. How does the automatic control circuit act to oppose an increase in a.c. generator voltage?

1. The saturated reactor current increases, causing an increase in amplidyne control field current
2. The pilot alternator voltage decreases, causing a decrease in amplidyne control field current
3. The pilot alternator voltage increases, causing an increase in amplidyne control field current
4. The saturated reactor current decreases, causing a decrease in amplidyne control field current

4-21. How does a decrease in generator frequency affect the reactances of the saturated reactor and the frequency compensation circuit?

1. The reactance of the saturated reactor increases, and the frequency compensation network behaves like an inductance
2. The reactance of the saturated reactor increases, and the frequency compensation network behaves like a capacitance
3. The reactance of the saturated reactor decreases, and the frequency compensation network behaves like an inductance
4. The reactance of the saturated reactor decreases, and the frequency compensation network behaves like a capacitance

4-22. At unity power factor, the compensating voltage across the compensating potentiometer rheostat is in phase with the

1. voltage across the teaser leg of the T-connected potential transformer secondary
2. resultant output voltage of the 3-phase response network
3. phase B line-to-neutral voltage
4. voltage across the resistor-inductor series circuit in the 3-phase response network

4-23. When two generators are being placed in parallel operation in a rotary voltage regulator system, load distribution and power factor are adjusted by means of the

1. manual control handwheels and prime mover governors
2. manual control handwheels and voltage adjusting unit
3. voltage adjusting unit and prime mover governors
4. voltage adjusting unit and saturated reactor tap switch

4-24. The amplidyne's short-circuiting brushes should be checked periodically because improper brush contact may result in an excessively high amplidyne voltage output.

1. True
2. False

Learning Objective: Recognize operating principles of the static excitation voltage regulator system and procedures for operating ship's service installations using this system.

IN ANSWERING QUESTIONS 4-25 THROUGH 4-27, REFER TO FIGURE 4-10 IN THE TEXTBOOK.

4-25. Why do switches S1 and S2 contain a large number of series-connected contacts?

1. To eliminate arcing when turned to the OFF position
2. To minimize arcing effects when power is removed
3. To provide multiple circuit path connections
4. To prevent the contacts from becoming hot

4-26. The output of the static exciter is controlled by the current through the

1. transformer primaries
2. transformer secondaries
3. transformer control windings
4. output rectifier CR1

4-27. The initial field current for starting the a.c. generator is provided by a field-flashing circuit from which of the following components?

1. The static exciter
2. The output rectifiers
3. A 50 kW, d.c. generator
4. All of the above

4-28. The automatic voltage regulator maintains the generator's output voltage by regulating the direct current through what part of the static exciter?

1. Control winding
2. Primary winding
3. Linear inductor
4. Secondary winding

IN ANSWERING QUESTIONS 4-29 THROUGH 4-34, REFER TO FIGURE 4-14 THROUGH 4-16 IN THE TEXTBOOK.

4-29. The reactance value of L6 in the voltage regulator is dependent on the

1. average of the line voltages
2. output of CR6
3. value of the secondary of T5
4. output of CW1

4-30. The amount of voltage across filter capacitor C1 is most nearly

1. proportional to the voltage drop across R8
2. equal to the output of T6
3. proportional to the line voltage average
4. equal to the amount of ripple when the line voltages are unequal

4-31. What condition will cause current to flow in the primary winding of CW4 in such a manner that exciter voltage will increase?

1. V_E equal to V_R and V_L
2. V_E greater than V_R
3. V_R greater than V_L
4. V_E greater than V_L

4-32. The amount of flux in the magnetic amplifier cores is controlled by what factor?

1. Output of transformer T5
2. Output of the comparison circuit
3. Amount of gated a.c. in CW5
4. Setting of voltage adjusting rheostat R6

4-33. When does maximum current flow in the magnetic amplifier load windings?

1. When the flux is zero
2. When the flux is greater than zero but the core is not saturated
3. When the core has been saturated by the control winding
4. When the core has been saturated by the load winding

4-34. Each magnetic amplifier is operated in the center portion of its magnetic core saturation curve by adjusting what components?

1. L7 and R13
2. R11 and R12
3. L6 and L7
4. R14 and R15

4-35. The amount of reactive droop can be increased by increasing the resistance of what resistor?

1. R2
2. R8
3. R12
4. R15

4-36. The control switch S1 should NEVER be left in an intermediate position between Manual and Automatic.

1. True
2. False

Learning Objective: Point out operating principles and maintenance requirements of an SPR-400 voltage regulator.

4-37. The purpose of the SPR-400 line voltage regulator is to ensure precision control of variations in which of the following factors?

1. Line voltage
2. Load changes
3. Power factor
4. All of the above

4-38. What effect does a decrease of direct current in the control winding have on the operation of the autotransformer?

1. The voltage in the opposing winding decreases and the output decreases
2. The voltage in the opposing winding decreases and the output increases
3. The voltage in the opposing winding increases and the output decreases
4. The voltage in the opposing winding increases and the output increases

4-39. The purpose of potentiometer R21 in figure 4-18 of the textbook is to compensate for the

1. resistance in the cables from regulator to load
2. internal resistance of the regulator
3. resistance of the regulator load
4. resistance of the input voltage

4-40. Frequent inspections for dust, dirt, and moisture must be made in an SPR-400 line voltage regulator.

1. True
2. False

IN ANSWERING QUESTIONS 4-41 AND 4-42, REFER TO FIGURES 4-19 AND 4-20 IN THE TEXTBOOK.

4-41. The K1 relay is energized for which of the following examples of phase angle (θ), voltage difference (ΔV), and frequency difference (ΔF)?

1. $\theta = -45°$; $\Delta V = 1\%$; $\Delta F = 0.1$ hz
2. $\theta = -22°$; $\Delta V = 3\%$; $\Delta F = 0.1$ hz
3. $\theta = 0°$; $\Delta V = 5\%$; $\Delta F = 0.5$ hz
4. $\theta = +5°$; $\Delta V = 5\%$; $\Delta F = 2.0$ hz

4-42. Assume that the synchronizing monitor is connected to a circuit consisting of two generators and that the K1 relay is energized. How does this affect the parallel operation of the generators?

1. The generators are automatically paralleled
2. The generators are not automatically paralleled but may be manually paralleled
3. The generators may not be paralleled while the K1 relay is energized but are automatically paralleled when it is de-energized
4. The generators may not be paralleled while the K1 relay is energized but may be manually paralleled when the relay is de-energized

IN ANSWERING QUESTIONS 4-43 THROUGH 4-46, REFER TO FIGURE 4-21 IN THE TEXTBOOK.

4-43. The reference bias voltage for Q1 in the synchronizing monitor appears across what component?

1. Capacitor C1
2. Resistor R2
3. Resistor R6
4. Zener diode CR8

4-44. The phase difference circuit turns Q1 off as a result of what action?

1. Reverse bias voltage across CR10
2. Reverse bias voltage across R6
3. Base-to-emitter short caused by the conduction of CR9
4. Base-to-emitter short caused by the conduction of CR10

4-45. The voltage difference circuit turns Q1 off as a result of what action?

1. Reverse bias voltage across Q5
2. Reverse bias voltage across R19
3. Base-to-emitter short caused by the conduction of CR18
4. Base-to-emitter short caused by the conduction of Q5

4-46. How is Q2 controlled?

1. By the phase difference circuit
2. By the frequency difference circuit
3. By simultaneous action of the voltage difference circuit and the frequency difference circuit
4. By either the voltage difference circuit or the phase difference circuit

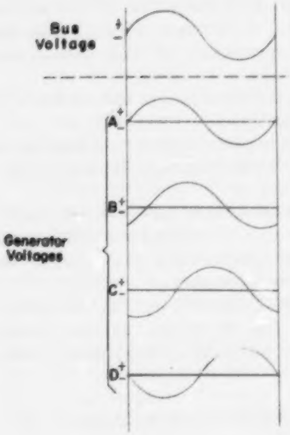

Figure 4A

IN ANSWERING QUESTION 4-47, REFER TO FIGURE 4A.

4-47. Which generator voltage occurring simultaneously with the indicated bus voltage will produce the maximum current flow in CR10 in the phase difference monitoring circuit of the synchronizing monitor?

1. A
2. B
3. C
4. D

4-48. K1 relay in the voltage difference monitoring circuit will NOT close if the voltage difference in the generators is more than

1. 5%
2. 2%
3. 3%
4. 4%

IN ANSWERING QUESTIONS 4-49 THROUGH 4-50, REFER TO FIGURE 4-27 IN THE TEXTBOOK.

4-49. The difference in the magnitude of the sensing signals from the oncoming generator and the bus is detected in bridge circuit

1. CR15
2. CR16
3. CR17 (points A and B)
4. CR18

4-50. What is the purpose of R19?

1. To prevent large voltage variations
2. To deenergize relay K1
3. To ensure that Q5 will remain off when relay K1 is deenergized
4. To ensure that Q5 will remain off when K1 is energized

4-51. Which of the following components in the frequency difference monitoring circuit (figure 4-29 of the textbook) are connected in such a way that a beat frequency voltage is produced between the oncoming generator and the bus?

1. Primaries of T2 and T3
2. Secondaries of T2 and T3
3. Secondaries of T2 and CR11
4. Transistors Q3 and Q4

4-52. Figure 4-30 of the textbook shows the results of various steps in the generation of a signal that is used to fire SCR1 in the frequency difference monitoring circuit. What is the purpose of the step that produces the waveform depicted by diagram E?

1. To produce a beat frequency voltage between the oncoming generator and the bus
2. To rectify and filter the beat frequency voltage
3. To assure that the clipped signal goes to zero when the original beat frequency voltage goes to zero
4. To assure that the clipped beat frequency signal maintains a constant d.c. level

4-53. Assume that a unijunction transistor has 0 volts on base 1 and 12 volts on base 2. If the transistor fires when the base 1-to-emitter voltage reaches 8 volts, the transistor has an eta value (intrinsic standoff ration) of

1. 1/3
2. 1/2
3. 2/3
4. 4/3

IN ANSWERING QUESTION 4-54, REFER TO FIGURES 4-29, 4-31, AND 4-32 IN THE TEXTBOOK.

- Study Hint: Assume that the difference in frequency between the oncoming generator voltage and the bus voltage is 0.2-Hz.

4-54. What is the time period for one cycle of the beat frequency voltage?

1. 0.5 time constant periods
2. 2.0 time constand periods
3. 2.5 time constant periods
4. 5.0 time constant periods

4-55. The function of the frequency differential circuit is to energize relay K1 through the control of transistor Q2.

1. True
2. False

4-56. High-power transistors that are noticeably hot while operating have been damaged beyond use.

1. True
2. False

4-57. What is the first connection you should make when using a signal generator as a transistor tester?

1. Connect the powerline to an isolation transformer
2. Connect the chassis of the signal generator to ground
3. Connect the chassis of the signal generator to the chassis of the equipment to be tested
4. Connect line voltage to signal generator

4-58. To prevent damage to a transistor use a signal tracer with a transformerless power supply.

1. True
2. False

4-59. Multimeters used for voltage measurements in transistor circuits should have a high ohms/volt sensitivity of at least

1. 5,000 ohms/volt
2. 10,000 ohms/volt
3. 15,000 ohms/volt
4. 20,000 ohms/volt

4-60. Ohmmeters will damage transistors if the meters are used in a range greater than

1. 0.25 ma
2. 0.50 ma
3. 0.75 ma
4. 1.00 ma

Assignment 5

Electrohydraulic Load-Sensing Speed Governors

Textbook Assignment: Pages 5-1 through 5-31

Learning Objective: Point out some of the functions of the general components in an electrohydraulic load-sensing governor.

5-1. On which type(s) of generator(s) has/have electrohydraulic governors been used successfully?

1. Steam turbine
2. Gas turbine
3. Diesel-driven
4. All of the above

5-2. A special feature that permits paralleling with other generators that have dissimilar governors is known as

1. speed droop
2. load-sensing
3. speed signal
4. steady state

5-3. What component correctly positions the steam valve or throttle in an electrohydraulic load-sensing governor?

1. Magnetic amplifier
2. Electrohydraulic actuator
3. Flyweight head assembly
4. Permanent magnet generator

5-4. An error signal is produced by which of the following circuits?

1. Speed signal circuits
2. Transistor amplifier circuit
3. Reference circuit
4. Frequency sensitive and reference circuit

IN ANSWERING QUESTIONS 5-5, REFER TO FIGURE 5-3 IN THE TEXTBOOK.

5-5. Changes in load are detected before they appear as speed changes by what equipment?

1. EGM control box
2. Permanent magnet generator
3. Load signal box
4. Resistor box

5-6. Most governing systems are designed so that any change in load produces a signal which is fed into the

(a)

resistor box, electronic amplifier

and this acts to offset any anticipated speed changes caused by

(b).

the prime mover, a load change

1. (a) resistor box
   (b) the prime mover
2. (a) electronic amplifier
   (b) a load change
3. (a) resistor box
   (b) a load change
4. (a) electronic amplifier
   (b) the prime mover

5-7. The steady state and transient frequency requirements for type II power can be met with electrohydraulic governors. However, a motor generator or static converter will still be required for type III voltage control.

1. True
2. False

IN ANSWERING QUESTION 5-8, REFER TO FIGURE 5-2 IN THE TEXTBOOK.

5-8. What is the working capacity of the EGR hydraulic actuator?

1. 20 ft/lb
2. 40 ft/lb
3. 80 ft/lb
4. 100 ft/lb

5-9. The droop switch allows parallel operation of prime movers with which of the following components?

1. Similar governors
2. Dissimilar governors
3. Infinite bus
4. All of the above

5-10. What couples the EGR hydraulic actuator to the remote servo piston?

1. Electrical cables
2. Mechanical linkage
3. High-pressure lines
4. Buffer piston

5-11. What component controls the flow of pressure oil to or from the servo piston?

1. EGR actuator
2. Power piston
3. Bypass hole
4. Control box

5-12. What will happen to the pilot valve plunger if a negative d.c. voltage is sent to the actuator from the electronic control box?

1. It will travel in a upward direction
2. It will travel in a downward motion
3. It will maintain its steady state position
4. It will hunt in a upward and downward motion

5-13. If the power piston is forced down the fuel to the prime mover will

1. increase
2. decrease
3. stop
4. remain the same

5-14. What quality of an electrohydraulic governor is enhanced by a temporary negative feedback signal?

1. Dependability
2. Stability
3. Reliability
4. Each of the above

5-15. What component allows the pressure differential on the two sides of the buffer piston and on the upper and lower sides of the compensating land to be dissipated by the flow of oil?

1. Relief valve plunger
2. Control land
3. Needle valve orifice
4. Lower buffer piston

5-16. What happens when a negative d.c. signal is sent to the actuator from the electronic amplifier?

1. Fuel increases
2. Fuel decreases
3. Fuel pressure is allowed to build
4. Fuel pressure is lowered

5-17. The power piston and its piston rod are surrounded by seal grooves. These grooves are used to ensure that any leakage of pressure oil from the power piston comes from a part of the hydraulic circuit where it can do no harm.

1. True
2. False

5-18. When using a hydraulic amplifier in conjunction with the EGR actuator, a remote servo piston is essential.

1. True
2. False

5-19. Control oil pressure is approximately
__(a)__ of the _____(b)_____
1/4, 1/2 compensation, residual
oil pressure.

1. (a) 1/4 (b) compensation
2. (a) 1/2 (b) residual
3. (a) 1/4 (b) residual
4. (a) 1/2 (b) compensation

5-20. When the electrical control unit senses an under speed condition, it signals for an increase in speed. To which port will the EGR actuator direct oil?

1. Port A
2. Port B
3. Port C
4. Port E

5-21. During which one of the following conditions will the oil control port be covered by the amplifier pilot valve plunger?

1. Increased fuel condition
2. Decreased fuel condition
3. On-speed condition
4. Shut down condition

5-22. When the electrical control unit signals for a decrease in speed, the valve plunger allows oil to drain from which port?

1. Port A
2. Port B
3. Port C
4. Port E

5-23. What is the minimum oil pressure required to move the hydraulic amplifier pilot valve plunger on start up?

1. 15 psi
2. 20 psi
3. 25 psi
4. 80 psi

5-24. The EGM control box is designed to provide the control signal to the electro-hydraulic transducer in the hydraulic actuator.

1. True
2. False

5-25. The input from the PMG is applied to the
___(a)___ section where it is converted
speed, work
into a ___(b)___ d.c. voltage.
negative, positive

1. (a) speed (b) positive
2. (a) work (b) negative
3. (a) speed (b) negative
4. (a) work (b) positive

5-26. If the speed setting potentiometer is adjusted to increase speed, it causes a voltage signal change in the positive direction to the base of which transistor?

1. Q1
2. Q4
3. Q6
4. Q8

5-27. An increase in potential at point B
causes Q5 to conduct ___(a)___ and
more, less
Q6 to conduct ___(b)___.
more, less

1. (a) more (b) less
2. (a) more (b) more
3. (a) less (b) more
4. (a) less (b) less

IN ANSWERING QUESTIONS 5-28 AND 5-29, REFER TO FIGURE 5-7 IN THE TEXTBOOK.

5-28. How is the turbine affected if the control box is disconnected at point I?

1. It stops
2. It speeds up
3. It hunts excessively
4. It slows down

5-29. An open at point J of the control box will cause

1. the prime mover to stop
2. a loss in reliability
3. a loss in stabilization
4. the speed of the prime mover to increase

5-30. What type of signal is converted by the load signal box to a positive d.c. voltage?

1. Single-phase
2. Single-phase parallel
3. Three-phase
4. Three-phase parallel

5-31. How many resistors are contained in the resistor box?

1. 9
2. 6
3. 3
4. 12

IN ANSWERING QUESTION 5-32, REFER TO FIGURE 5-10 IN THE TEXTBOOK.

5-32. What component is used to vary the amplitude of the signal?

1. LOAD PULSE ADJ
2. GAIN ADJ
3. DROOP ADJ
4. RESISTOR BOX

5-33. The load pulse signal is initially maximum and gradually decreases to zero.

1. True
2. False

5-34. What must be done to the load signal box when two generators are operating in parallel with dissimilar type governors?

1. Turn the droop switch ON
2. Turn the droop switch OFF
3. Adjust the load pulse potentiometer
4. Adjust the gain potentiometer

5-35. What are the input voltage limits across the hydraulic actuator of a single operating unit?

1. +0.50 to -0.50 V d.c.
2. +5.00 to -0.50 V d.c.
3. +0.25 to -0.25 V d.c.
4. +2.50 to -2.50 V d.c.

5-36. What is the source of most of the troubles in the hydraulic actuator of a load-sensing governor?

1. Unit out of adjustment
2. Defective control box
3. Faulty actuator
4. Dirty hydraulic oil

Learning Objective: Point out some of the functions of the EGB-2P governor/actuator and the 2307 load and speed-sensing control.

5-37. The EGB-2P has how many internal sections?

1. Five
2. Two
3. Three
4. Four

5-38. If the electric control should fail, what component is designed as a back-up?

1. The transducer
2. The manual control
3. The ball head section
4. The feedback section

5-39. The oil supply for the EGB-2P actuator is obtained from which of the following sources?

1. The engine lubricating system
2. The external oil sump
3. Both 1 and 2 above
4. The self-contained sump

5-40. What will the actuator do, if anything, when there is an electrical failure?

1. Increase to maximum fuel
2. Decrease to minimum fuel
3. Shut the fuel off
4. Nothing

5-41. What component controls the flow of oil to and from the power piston?

1. Compression spring
2. Control land
3. Restoring lever
4. Pilot valve plunger

5-42. What effect will an increase in engine or turbine speed have on the signal from the electric control?

1. It will decrease
2. It will increase
3. It will remain the same
4. It will increase to a steady state

5-43. What component allows the oil pressure to equalize above and below the compensation land?

1. Bypass porting
2. Check valve
3. Pivot pin
4. Needle valve orifice

5-44. The speed at which the governor controls the engine is determined by the loading or compression of the speeder spring.

1. True
2. False

5-45. Speed droop is defined as the decrease in speed taking place when the governor output shaft moves from the minimum to the maximum position in response to a load increase.

1. True
2. False

Learning Objective: Identify some of the different components of the 2301 Electric Governor and operating procedures.

5-46. How many different components make up the 2301 Electric Governor?

1. One
2. Two
3. Three
4. Four

5-47. What component controls the rate of acceleration during initial start-up?

1. The ramp generator module
2. The load sensor
3. The proportional actuator
4. The mode switch

5-48. What part of the load sensor computes the kW load on the generator?

1. The burden resistors R-1, R-3
2. The rectifiers
3. The voltage adder circuit
4. The load sensor input transformer

5-49. What component of the 2301 provides the a.c. input signal to the speed sensor

1. The speed reference module
2. The voltage regulator
3. The magnetic pick-up
4. The load sensor module

5-50. The ramp generator biases the speed signal to control the rate of acceleration of the prime mover from idle to rated speed.

1. True
2. False

IN ANSWERING QUESTION 5-51, REFER TO FIGURE 5-15 IN THE TEXTBOOK.

5-51. To what component is the output signals from the load sensor, the speed sensor, the speed setting potentiometer and the ramp generator applied?

1. The summing point of the sensor module
2. The summing point input of amplifier A1
3. The input of amplifier A2
4. The terminal board TB4

5-52. What is/are the correct supply voltage(s) for the 2301 electric control?

1. 24 V a.c.
2. 32 V d.c.
3. 24 V d.c.
4. Both 2 and 3 above are correct

5-53. What component of the 2301 electric control protects against reverse biasing?

1. Resistor R18
2. Transistor Q4
3. Diode CR1
4. Transistor A1Q1

5-54. What are the correct operating voltages for the 2301 electric control system?

1. + 9 and - 9 V d.c.
2. + 9 and - 9 V a.c.
3. +24 and -24 V d.c.
4. +32 and -32 V d.c.

5-55. What voltage is provided by Zener diode A1A1VR1 for the speed setting control?

1. 4.5 V d.c.
2. 6.6 V d.c.
3. 7.5 V d.c.
4. 9.0 V d.c.

5-56. At what terminal is the input signals from the various input and control circuits algebraically added together in the amplifier?

1. Five
2. Two
3. Three
4. Four

5-57. What will happen, if anything, to the differential amplifier if the input transistor A1A1Q1 is turned on and conducts?

1. It will shut down
2. It will overheat
3. It will become unbalanced
4. Nothing

5-58. The differential amplifier is set to call for an increase in fuel. What potential will be felt at terminal 3?

1. -18 V
2. - 9 V
3. + 9 V
4. +18 V

5-59. What is the function of potentiometer A1R2 in the amplifier?

1. It varies the charging rate of A1A1C10
2. It varies the charging rate of A1A1C4
3. It varies the discharge rate of A1A1C10
4. It varies the discharge rate of A1A1C11

IN ANSWERING QUESTION 5-60, REFER TO FIGURE 5-17 IN THE TEXTBOOK.

5-60. The ramp generator is in ACCELERATION MODE. What potential will be felt at terminal 4?

1. - 9.0 V
2. - 8.4 V
3. + 0.6 V
4. + 9.0 V

5-61. What component of the speed sensor determines the time of conduction for A4Q3?

1. A4R10
2. A4R2
3. A4CR3
4. C1

5-62. What is the amount of bias potential for the speed sensor?

1. 18.0 V d.c.
2. -15.6 V d.c.
3. 9.0 V d.c.
4. - 2.4 V d.c.

5-63. When operating in parallel with another generator, what signal will be sent to Unit 1 and Unit 2 summing points if unit 1 is 80 percent loaded and Unit 2 is 95 percent loaded?

1. Positive to Unit 1 and negative to Unit 2
2. Positive to Unit 1 and positive to Unit 2
3. Negative to Unit 1 and positive to Unit 2
4. Negative to Unit 1 and negative to Unit 2

Assignment 6

Visual Landing Aids: Auxiliary Propulsion Equipment

Textbook Assignment: Pages 6-1 through 6-20 and pages 7-1 through 7-9

Learning Objective: Identify components of the visual landing aids by their function.

6-1. Which of the following functions describes the reason(s) that air capable ships (ACS) required the development of visual landing aids (VLA) to assist helicopter operations?

1. To provide visual contact with the ship
2. To provide a safe glide path to the landing area
3. To aid the pilot in operating under more demanding environmental conditions
4. All of the above

6-2. What is the stabilized glide slope indicator (GSI) system?

1. A mechanical light
2. A hand-hold landing instrument
3. An electrohydraulic optical landing aid
4. A group of pulsating lights

6-3. The glide slope indicator provides what three colors of light bars?

1. Red, green, and white
2. Red, green, and amber
3. Blue, green, and white
4. Blue, green, and amber

6-4. An approaching helicopter pilot sees only a green light. What does this indicate?

1. He is too high
2. He is too low
3. His approach is correct
4. He is being waved off

6-5. The stabilized glide slope indicator (GSI) is essentially a servo loop.

1. True
2. False

6-6. What is the function of the gyro on the stabilized platform of the GSI?

1. To hold the platform stable by the use of locking bars
2. To provide heading information to the pilot
3. To furnish reference information to the servo loop
4. To stabilize the light beam

6-7. In the normal operating mode, where is the error signal changed from a.c. to d.c.?

1. Gyro demodulator
2. Stab-lock relay
3. Servo amplifier
4. LVDT demodulator

6-8. The amplified d.c. signal produced by the servo amplifier is used to operate what component?

1. Hydraulic actuator
2. Servo valve
3. Servo pump
4. LVDT demodulator

6-9. When the stab-lock button is pushed, the normal error signal supplied from the gyro is stopped.

1. True
2. False

IN ANSWERING QUESTION 6-10, REFER TO FIGURE 6-10 IN THE TEXTBOOK.

6-10. What component generates the error voltage that determines the position of the stable platform.

1. Manual control pot
2. Error detector
3. LVDT
4. Amplifier

IN ANSWERING QUESTION 6-11 THROUGH 6-13, REFER TO FIGURE 6-11 IN THE TEXTBOOK.

6-11. The remote control panel assembly contains how many light dimmer controls?

1. One
2. Two
3. Three
4. Four

6-12. On the remote control panel, the OVER TEMP light will illuminate when the hydraulic fluid reaches what temperature?

1. 115°F ±5°
2. 135°F ±5°
3. 155°F ±5°
4. 175°F ±5°

6-13. On the remote control panel, what does the standby lamp indicate?

1. That the main switch is energized
2. That the source light is energized
3. That power is available to the main switch
4. That the hydraulic fluid is up to operating temperature

6-14. At what pressure will the low-pressure relay be closed?

1. 1200 psi
2. 1300 psi
3. 1400 psi
4. 1450 psi

6-15. Hydraulic fluid heaters in the oil reservoir will warm the fluid up to what temperature?

1. 70°F ±5°
2. 90°F ±5°
3. 110°F ±5°
4. 130°F ±5°

6-16. The output of the transformer assembly is 0 to 18.5 volts a.c.

1. True
2. False

6-17. The lamp house assembly of the GSI contains which of the following components?

1. One lamp and a vent fan
2. Three lamps, two heaters, and an optical lens
3. Three lamps and a vent fan
4. Two heaters, a thermostat, and three lamps

6-18. What is the purpose of the cooling fan?

1. To cool the Fresnel lens
2. To cool the light tunnel
3. To cool the temperature control section
4. To cool the lamp house assembly

6-19. The Fresnel lens is maintained at a constant temperature of 115°F ±15°.

1. True
2. False

6-20. The stabilized GSI system will compensate for pitch, roll, and heave to keep the platform positioned correctly?

1. True
2. False

6-21. The vertical gyroscope is basically what type of device?

1. A mechanical device
2. An electrical device
3. A hydraulic device
4. An electrohydraulic device

6-22. The gyroscope's pendulum sensor is attached under what part?

1. Magnetic sensor
2. Gimbal structure
3. Spinning flywheel
4. Stabilized platform

6-23. The magnetic sensor of the vertical gyroscope measures the difference between the pendulum axis and the

1. rotating flywheel
2. torque motor
3. roll angle indicator
4. spin motor axis

6-24. The GSI system incorporates an independent failure detection circuit that detects which of the following malfunctions?

1. Low voltage
2. Loss of power
3. Loss of platform stabilization
4. Roll-angle indicator

6-25. The output of the LVDT is directly proportional to the ship's motion.

1. True
2. False

6-26. What is the color of the high-intensity homing beacon light?

1. Blue
2. Red
3. Amber
4. White

6-27. What voltage is used to illuminate the homing beacon lamp?

1. 440 V a.c.
2. 230 V a.c.
3. 115 V a.c.
4. 32 V a.c.

6-28. Edge lights are red omnidirectional lamps which can be seen in any direction.

1. True
2. False

6-29. How is the dimmer for the edge lights connected?

1. In series with a rheostat
2. The primary of the transformer is connected to a dimmer rheostat
3. The primary of the transformer is connected to a variable transformer
4. The secondary of the transformer is connected to a rheostat

6-30. How is the flash sequence for the line-up lights connected?

1. In series with the variable transformer
2. In series with the 115/6.5 volt transformer
3. Both 1 and 2 above
4. In parallel with the line-up lights

6-31. What color are the extended line-up lights?

1. Amber
2. White
3. Green
4. Red

6-32. Where are the vertical drop-line lights located?

1. Aft of the line-up lights
2. Forward of the line-up lights
3. Across from the touchdown light
4. Up from the forward end of the line-up lights

6-33. All floodlights forward of the landing area must be extinguished so as not to interfer with the pilot's depth perception.

1. True
2. False

6-34. Maintenance floodlights for preflight and postflight are prohibited from use outside the hangar after sunset.

1. True
2. False

6-35. Where is the master control panel of the wave off light (WOL) located?

1. In the helicopter control station
2. At the captain's bridge control station
3. At the remote control station on the boat deck
4. On the fan tail

IN ANSWERING QUESTION 6-36, REFER TO FIGURE 6-24 IN THE TEXTBOOK.

6-36. How many operating stations are associated with the WOL?

1. Five
2. Two
3. Three
4. Four

6-37. Which of the following is/are the purpose(s) of the three yellow HIFR lights?

1. To indicate ship's heading
2. To indicate height
3. Both 1 and 2 above are correct
4. To indicate helicopter's heading

6-38. HIFR lights are installed
____________(a)____________and
port to starboard, forward to aft
spaced approximately ______(b)______
10 ft, 20 ft
apart.

1. (a) Port to starboard (b) 10 ft
2. (a) Forward to aft (b) 10 ft
3. (a) Port to starboard (b) 20 ft
4. (a) Forward to aft (b) 20 ft

6-39. What is used to control all HIFR lights?

1. An on/off switch
2. A rheostat
3. A motor driven transformer
4. A transformer rheostat

6-40. What prevents the VERTREP lights and the line-up lights from being illuminated at the same time?

1. Transformer cannot carry the load
2. The two sets of lights are at right angles to each other
3. The switching arrangement prevents illuminating both sets of lights simultaneously
4. The fuses will prevent operating both circuits at once

6-41. The VLA lighting control system has how many motor-driven remote variable transformers?

1. Five
2. Six
3. Three
4. Four

6-42. Transformers, rated at 22-amperes are used to power the overhead and deck-surface floodlights?

1. True
2. False

6-43. What are the inputs to the detector circuit?

1. 1 a.c. and 1 d.c signal
2. 2 a.c. signals
3. 2 d.c. signals
4. 1 d.c. signal

Learning Objective: To learn the different components and their functions of a retractable auxiliary propulsion system.

6-44. Which of the following is an objective for the installation of auxiliary propulsion equipment onboard naval ships?

1. To increase ships top speed
2. To provide maneuverability
3. To eliminate the use of tugs
4. Each of the above

6-45. How many auxiliary propulsion motors are located on the FFG class ships and where are they located?

1. One unit, mounted on the bow
2. One unit, mounted on the stern
3. Two units, mounted port and starboard
4. Three units, mounted bow, mid-ships, and stern

6-46. What is used to fill the stator cavity?

1. Compressed air
2. Liquid rubber
3. Non-conducting oil
4. Epoxy polyester resin

6-47. The rotor of an APM is open at both ends so that saltwater may act as a cooling agent.

1. True
2. False

6-48. What type of metal is used to construct the housing of an APM?

1. Copper-bronze
2. Stainless steel
3. Cast nickel-aluminum bronze
4. Cast copper-aluminum bronze

6-49. By what means are the housing and bearings of an APM cooled.

1. By a fresh water pump
2. By compressed air
3. By an oil flow
4. By sea water

6-50. There are no strainers or filters in the cooling vent holes of an APM?

1. True
2. False

6-51. How many pounds of thrust is developed by the propeller of an APM with zero forward velocity?

1. 6,500 lb
2. 9,000 lb
3. 12,000 lb
4. 15,500 lb

6-52. A ball screw drive assembly greatly reduces thread friction and provides what efficiency?

1. No greater than 70%
2. No greater than 80%
3. No greater than 85%
4. 90% or greater

6-53. What part(s) is/are used to connect the double-reduction gear housing to the single-reduction housing?

1. An idler shaft
2. A chain linkage
3. A dual belt pulley
4. Hydraulic lines

6-54. The first gear set in the double-reduction-gear housing provides a
____(a)____ speed reduction through
10 to 1, 20 to 1
its ____(b)____ gear set.
worm, bevel

1. (a) 10 to 1 (b) bevel
2. (a) 20 to 1 (b) worm
3. (a) 10 to 1 (b) worm
4. (a) 20 to 1 (b) bevel

6-55. What is the overall reduction in speed and torque amplification of the two gear housings?

1. 25 to 1
2. 50 to 1
3. 75 to 1
4. 100 to 1

6-56. What is the maximum pounds of vertical force generated by the gear and ball screw arrangement?

1. 50,000 lb
2. 75,000 lb
3. 90,000 lb
4. 100,000 lb

6-57. By what means may the APM be trained if the training motor is NOT operative?

1. By auxiliary training motor
2. By block and tackle
3. By hydraulic rams
4. By hand crank

6-58. The APM may be safely operated at which of the following ship speeds?

1. 5 knots
2. 10 knots
3. Both 1 and 2 above
4. 15 knots

6-59. If the main column of the TRD should become totally filled with water, how would this effect the power system?

1. APM would oscillate
2. Training motor will not function
3. Grounded power system
4. No effect

6-60. To retract the APM, the thrust direction indicator must be in what position?

1. 0°
2. 90°
3. 180°
4. 270°

6-61. The fine train limit switches on the training and retracting device is closed when the APM is in what position?

1. 0°
2. 90°
3. APM fully extended
4. APM fully operational

6-62. In normal electrical operation, the manual retracting crank override limit switch on the TRD has closed contacts in series with what push button?

1. APM start-up
2. Main power
3. Unit retract
4. Stop solenoid

6-63. If low voltage or loss of power should occur during the retraction of the APM, which of the following actions, if any, must the operator perform?

1. It must be fully lowered and then retracted when power is restored
2. The APM must be returned to zero degrees when power is restored
3. The unit retract push button on the control box must be pressed when power is restored
4. None, it will start-up automatically when power is restored

6-64. At the remote control box, which of the following actions may you perform with the APM?

1. Raise and lower
2. Start and stop
3. Train
4. Either 2 or 3 above

6-65. What value and type of voltage is used for control power?

1. 110 V a.c.
2. 110 V d.c.
3. 450 V a.c.
4. 450 V d.c.

6-66. What should be your first concern before lowering the APM and TRD for test operation?

1. The power available
2. If sufficient personnel are available
3. The depth of water under the ship
4. The degree of angle on the APM

6-67. Which of the following lamp(s) will illuminate when the main circuit breaker is turned on?

1. Main power CB on lamp
2. Unit retracted lamps
3. Zero position lamp
4. Each of the above

6-68. What push button on the local control box will release the retracting motor brake?

1. Unit extend
2. Brake release
3. Training
4. Power on

6-69. What will stop the retracting motor once it is started?

1. Limit switches on TRD
2. Hoist-stop push button
3. Both 1 and 2 above
4. Mechanical stops

6-70. How does the operator know in which direction the APM is pointed?

1. By the mechanical indicator on the TRD
2. By the bridge lookout's report
3. By the electrical indicator on bridge
4. By the thrust direction indicator

6-71. Both APM's should NEVER be operated simultaneously at these angles (port APM at 270°, starboard APM at 90°).

1. True
2. False

6-72. Whenever the APM is started, the bridge should be notified so that a time running log may be maintained.

1. True
2. False

6-73. What is the rated motor current for a single APM?

1. 350 amp
2. 400 amp
3. 500 amp
4. 540 amp

6-74. An operator should NEVER exceed three starts in rapid succession or
______(a)__ starts per minute with less
three, six
than a ____(b)______ off period
5 sec, 10 sec
between starts.

1. (a) Three (b) 5 sec
2. (a) Three (b) 10 sec
3. (a) Six (b) 5 sec
4. (a) Six (b) 10 sec

6-75. Which of the following indicators will de-energize when the stop push button is pressed?

1. Motor current meter
2. Propulsion motor CB on lamp
3. Propulsion motor operating time meter
4. All of the above

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NRCC ELECTRICIAN'S MATE 1 & C
NAVEDTRA 10547-E

PRINT OR TYPE

NAME ______________________________ ADDRESS ______________________________
Last First Middle Street/Ship/Unit/Division, etc.

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City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ______________ DATE MAILED ________

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PRINT OR TYPE

NRCC ELECTRICIAN'S MATE 1 & C
NAVEDTRA 10547-E

NAME ______________________________ ADDRESS ______________________________
Last First Middle Street/Ship/Unit/Division, etc.

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City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ________________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ________________ DATE MAILED ________

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PRINT OR TYPE

NRCC ELECTRICIAN'S MATE 1 & C
NAVEDTRA 10547-E

NAME ____________________ ADDRESS ____________________
Last First Middle
Street/Ship/Unit/Division, etc.
____
City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ____________________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ____________________ DATE MAILED ________

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NRCC ELECTRICIAN'S MATE 1 & C
NAVEDTRA 10547-E

PRINT OR TYPE

NAME ______________________________ (Last) (First) (Middle)
ADDRESS ______________________________ Street/Ship/Unit/Division, etc.
______________________________ City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ______________________ DESIGNATOR ________ ASSIGNMENT NO. ________

☐ USN ☐ USNR ☐ ACTIVE ☐ INACTIVE OTHER (Specify) ______________ DATE MAILED ________

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PRINT OR TYPE

NRCC Electrician's Mate 1 & C
NAVEDTRA 10547-E

NAME ______________________________ ADDRESS ______________________________
Last First Middle
Street/Ship/Unit/Division, etc.
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City or FPO State Zip

RANK/RATE ________ SOC. SEC. NO. ________________ DESIGNATOR ________ ASSIGNMENT NO. ________

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PRINT OR TYPE

NRCC Electrician's Mate 1 & C
NAVEDTRA 10547-E

NAME ______________________ ADDRESS ______________________
Last First Middle
Street/Ship/Unit/Division, etc.
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City or FPO State Zip
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